JOURNAL OF MAMMALOGY

VOL. 36 MAY 1955 NO. 2

UNIVERSITY OF MICHIGAN
JUN ~ 1955
SCIENCE LIBRARY

AMERICAN SOCIETY OF MAMMALOGISTS

The American Society of Mammalogists

Founded April 3, 1919

Incorporated April 29, 1920

Officers

WILLIAM H. BURT, *President*
ROBERT T. ORR, WILLIAM B. DAVIS, *Vice-Presidents*
RANDOLPH L. PETERSON, *Recording Secretary*
GEORGE C. RINKER, *Corresponding Secretary*
CAROLINE A. HEPPENSTALL, *Treasurer*
W. ROBERT EADIE, *Editor*

Additional Directors

1953–1955	1954–56
VIOLA S. SCHANTZ	KEITH R. KELSON
EMMET T. HOOPER	DONALD F. HOFFMEISTER
J. KENNETH DOUTT	STEPHEN D. DURRANT
OLIVER P. PEARSON	ANTOON DE VOS
ROBERT H. COLEMAN	HOBART M. VAN DEUSEN

Past Presidents

HAROLD E. ANTHONY	E. RAYMOND HALL
H. H. T. JACKSON	REMINGTON KELLOGG
WALTER P. TAYLOR	TRACY I. STORER
A. BRAZIER HOWELL	WILLIAM J. HAMILTON, JR.

Trustees

STEVEN S. GREGORY, JR. (1957) WILLIAM P. HARRIS, JR. (1956) COLIN C. SANBORN (1955)

Standing Committees 1952–1953

Bibliography: David H. Johnson, *Chairman*. Claude W. Hibbard, Charles P. Lyman, Richard H. Manville, Henry W. Setzer.

Conservation of Land Mammals: A. Starker Leopold, *Chairman*. Helmut K. Buechner, Clarence Cottam, Fred W. Johnson, William O. Pruitt, Jr., Antoon de Vos.

Editorial: W. Robert Eadie, *Chairman*. Don W. Hayne, Claude W. Hibbard, Donald F. Hoffmeister, William A. Wimsatt.

Honoraria for Graduate Students: W. Robert Eadie, *Chairman*. Frederick S. Barkalow, Jr., Stephen D. Durrant, Robert T. Orr.

Index of Journal of Mammalogy: Viola S. Schantz, *Chairman*. Charles O. Handley, Jr., David H. Johnson, Remington Kellogg.

Marine Mammals: Robert T. Orr, *Chairman*. H. Dean Fisher, Raymond M. Gilmore, Carl L. Hubbs, Gordon C. Pike, Joseph C. Moore.

Membership: A. R. Shadle, *Chairman*. W. B. Robinson, W. B. Davis, Antoon de Vos, Kenneth L. Duke, Arthur Svihla, Richard Van Gelder.

Nomenclature: Colin C. Sanborn, *Chairman*. Raymond M. Gilmore, E. Raymond Hall, Donald F. Hoffmeister, Ralph S. Palmer.

The American Society of Mammalogists is an affiliate of the A. A. A. S. and the National Research Council, and an exchange member of the Nature Conservancy.

The Journal of Mammalogy

Journal of Mammalogy is published quarterly by the American Society of Mammalogists, Mt. Royal and Guilford Aves., Baltimore 2, Md.

Persons actively interested in mammalogy may become members of the Society upon nomination, payment of membership dues, and election. Applications for membership may be obtained from the corresponding secretary. The Journal of Mammalogy is sent free to all members of the American Society of Mammalogists not in arrears for dues ($4.00).

Subscription rates are $6.00 per year; single numbers of the Journal are $1.50 each.

Nominations and dues for membership, dues for subscriptions, changes of addresses, orders for back numbers and the two bound indexes, requests for missing numbers, and applications for advertising rates should be addressed to the Corresponding Secretary, George C. Rinker, Department of Anatomy, University of Michigan, Ann Arbor, Michigan.

Publications for inclusion in the bibliography of mammalogical literature, section on "Recent Literature," should be sent to David H. Johnson, Division of Mammals, U. S. National Museum, Washington, D. C.

Manuscripts for publication, books for review, and papers for special comment should be sent to the Chairman of the Editorial Committee, W. Robert Eadie, Fernow Hall, Cornell University, Ithaca, New York.

Entered as second class matter, November 20, 1919, at the Postoffice, Baltimore, Md., under the act of March 3, 1879.

Made in United States of America

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 36 MAY —, 1955 NO. 2

A REVISED CLASSIFICATION OF THE RODENTS

BY ALBERT E. WOOD

Of all the orders of mammals, the rodents are the most inadequately understood taxonomically. Almost everyone who has worked with the rodents is in agreement that the current classification is inadequate. But, at least partly because of the large number of different forms belonging to this order, there is no general agreement as to what is wrong with the present arrangement or what should be done to improve it. The present author has been thinking about this problem for a considerable period, and had hoped to be able to present a consistent revision of the subordinal classification, with adequate documentation. However, it seems apparent that it will be a long time, if ever, before anyone will have been able to acquire a first-hand knowledge of all of the members of this order, and therefore the suggested arrangement in this paper is merely presented as a basis for further discussion by others who are interested in this order, in hopes that this will contribute to a better understanding of the problems of rodent taxonomy and a closer approach to a realistic classification.

There seem to be two general philosophies underlying current classifications. Nearly everyone accepts the theoretical ideal that a classification should reflect the underlying relationships of the animals involved. But it is not always possible to agree on the criteria that should be used to interpret the relationships. An attempt to use this principle is exemplified by Simpson (1945). The difficulty with using relationships of the organisms involved is that there are always some forms of uncertain relationships. These must either be assigned a position in the classification in a more or less arbitrary manner, or they must be left *incertae sedis*. While this latter method gives the most adequate picture of the relationships of the forms involved, it is definitely unsatisfactory from many points of view, particularly since there are an unusually large number of rodents that would have to be left *incertae sedis*. Therefore, there is always a tendency to fall back on the other type of classification, which involves the use of key characters, and sets up a classification based on arbitrary criteria, into which all forms can fit. This type of arrangement is the standard, classical classification of rodents, and has recently been strongly advocated by Ellerman (1940). This solves the problems of where to place all the families of rodents, but leaves many of them in positions that do not seem correct from the phylogenetic point of view.

Obviously, if it were possible to work out the evolution of the rodents in detail, by tracing the paleontologic history of the individual genera and families, this would give a basis for a correct picture of the relationships of the order. From a knowledge of the relationships, a classification could be made on which there might be agreement, although even then it would not be unanimous. But we are a long way from knowing enough about the paleontologic history of the order to be able to trace such detailed relationships. For many years, there was a rather sharp break in rodent history at the Eocene-Oligocene boundary. The Eocene families could be traced up to this point, where, with the exception of a few stragglers, they died out. The late Tertiary and Recent forms could not be traced back beyond the Middle or Lower Oligocene. One or two families, such as the Eomyidae and Theridomyidae, bridged the gap, but there has been no general agreement as to their phylogenetic significance, and they do not continue down to the present. While Matthew's phylogenetic chart (1910, fig. 19) showed a complete tie-in of the two groups, this was merely a well-educated guess on his part, and its truth has not been demonstrated by finding the intermediate forms. To a certain extent, this situation still holds, particularly for the families of African rodents, whose fossil history is at best inadequately known. Nevertheless, recent work on the fossil members of the order is beginning to permit the tracing of a few connections across the Eocene-Oligocene boundary, with greater or lesser certainty.

One of the results of this detailed paleontologic work is the demonstration that parallelism in rodents, which rodent specialists have stressed for many years, extends to the structure of the infraorbital region, as well as to that of the teeth. The so-called "Sciuromorph" pattern was shown by Wood (1937), to have been developing independently in *Titanotheriomys*, a rodent that could not be ancestral to the "Sciuromorphs." Wood (1950) and Wood and Patterson (in press) have adduced strong evidence that the South American "Hystricomorphs" have developed their zygomasseteric structure independently of that in the Old World "Hystricomorphs." Lavocat (1951) has shown that the Theriodmyidae could not be ancestral to the Old World "Hystricomorphs," but must have developed their structural similarities independently.

These results indicate that the whole basis for the calssification of rodents must be revised, and that no classification based on any key characteristics is likely to agree with one based on the phylogeny of the order. In the present study, the approach has intentionally been entirely from the phylogenetic point of view. It is assumed that any or all morphologic characters may have developed once, or a hundred times independently, in the rodents, and that no morphologic criteria or combinations of criteria should be relied upon until they have been demonstrated by phylogenetic studies to be valid. Admittedly, this is a novel point of view, and open to attack. But it is felt to be justifiable because of its novelty, since no previous classification, based on the strictly morphological approach, is acceptable.

Obviously, at the present time the phylogenetic data are inadequate for many families of the order. For this reason, it is obvious that in many cases the arrange-

ment herein suggested is certain to be erroneous. But the stress here is on the development of similar physical features, independently, in diverse and geographically isolated groups of rodents. Whether or not the details of the present classification are fortuitously correct, it is believed that progress will have been made if it can be shown that the classical "Sciuromorpha," "Myomorpha" and Hystricomorpha" are not natural groups. This is by no means a novel or original idea, as is pointed out below, but it is nevertheless well worth emphasizing. Stehlin and Schaub (1951), and Schaub (1951, 1953*a* and 1953*b*) have particularly stressed the heterogeneity of the three classic suborders.

Perhaps the present paper should be viewed as a last attempt to prepare a subordinal arrangement of rodents. If the proposed arrangement should meet with general disapproval, it would probably be advisable to throw out everything above the level of the superfamily until we know much more about rodent paleontology and evolution.

HISTORY OF RODENT CLASSIFICATION

Simpson (1945, p. 200) suggests that there has been rather general agreement by most authors on what he calls the "classical" arrangement into three suborders. Actually, although this has been the standard arrangement of the order in most textbooks whose authors were not specialists on rodents, there has been no such general agreement among students of the order.

Brandt (1855) first proposed the division of the Simplicidentate rodents (i.e., the animals now included in the order) into the Sciuromorpha, Myomorpha, and Hystricomorpha, although de Blainville (1834) may have had the same general idea in mind. This division was primarily on the basis of the manner of development of the zygoma and the masseter muscle, the Sciuromorpha being those forms in which part of the masseter extends onto the face in front of the zygoma; the Hystricomorpha those in which part of the muscle passes through the infraorbital foramen, spreading its origin out onto the snout in front of the foramen; and the Myomorpha those in which the masseter does both. This classification has been rather generally followed, and is the one that Simpson adopts and calls the classical approach.

Tullberg (1899) felt that the three-fold division of the rodent order was not correct, and divided it into two major groups, the Sciurognathi and the Hystricognathi, on the basis of the inflection or lack of inflection of the angle of the lower jaw. These were divided into the Sciuromorphi and Myomorphi, and the Hystricomorphi and Bathyergomorphi, respectively, on the basis of the structure of the infraorbital foramen and the masseter muscle.

Schlosser (1884) was the first author to make a really comprehensive review of the fossil rodents. He placed all forms in Brandt's three suborders, relying to a very large extent on the patterns of the cheek teeth.

Matthew (1910, fig. 19) gives a phylogenetic tree of the New World rodents, summarizing most of the fossil data then available, but omitting all the Old World forms, many of which are the ones that present the greatest problems of classification.

Miller and Gidley, in their revision of the supergeneric groups of rodents (1918), were closest to the present paper in their general philosophy as to the problems of rodent classification. Their attempt to cut the Gordian knot of the Brandt classification was a radical one, with as inadequate documentation as is given here. They indicated that their presentation was a summary of a larger work to be published, which never appeared, presumably because of the magnitude of the project and the lack of paleontologic documentation of most of their conclusions. As Simpson (1945, p. 199) points out, their use of key characters resulted "in some separations and some collocations that can hardly correspond with real phylogenetic relationships."

Winge (1924) recognized the impossibility of dividing the rodents into three or four groups with any reasonable likelihood of the arrangement being correct, and so split them into eight groups, some of which agree with those presented here, and others of which do not. Again, there was no adequate phylogenetic basis. Although there may be superficial resemblances between the present classification and his, there is more paleontologic support for the present proposals. Like Miller and Gidley's, Winge's classification was an attempt to avoid the difficulties of the classical approach.

Wood (1937) presented a classification of North American rodents, based on the Brandt threefold classification, but proposing a fourth suborder for those rodents whose masseters had acquired no specializations but retained an origin limited to the zygoma, where it normally is in mammals. For this group, he revived the term Protrogomorpha proposed by Zittel (1893), but in quite a different sense.

Ellerman (1940) returned to the Tullberg classification. His is the outstanding example of a key-character classification, but it does not have the phylogenetic background that must be necessary to the adequate understanding of the relationships of the order. He generally omits the fossils from consideration.

Simpson's classification (1945) is the latest attempt to marshall the rodents into the Brandtian threefold classification, although he clearly indicates that several of his groups could be put elsewhere almost equally well. He included Wood's Protrogomorpha in the Sciuromorpha as the Aplodontoidea.

Wilson (1949*a*) reviewed the earlier fossil rodents of North America. He proposed no modification of Simpson's classification, but pointed out many places where that classification breaks down, and made many interesting suggestions of probable relationships, some of which (especially with regard to the content of the Myomorpha) have been incorporated in the present classification.

Stehlin and Schaub (1951) in their magnificent review of the dental characters of rodents, have pointed out many places where the three-fold classification of rodents will not work. In the systematic section (by Schaub), general comments on the disadvantages of the three-fold system, and specifically the problems of the Sciuromorpha, are given. Then Schaub says, "Ähnlich wie bei den 'Sciuromorphen' scheint mir auch bei den 'Myomorphen' der Zusammenhang der drei grossen Superfamilien, Dipodoidea, Gliroidea und Muroidea, höchst problematisch geworden zu sein." (Stehlin and Schaub, 1951, p. 365.) No alternative arrangement is specifically presented, though many suggestive hints are dropped throughout the paper. Although it might be possible to combine these and arrive at an interpretation of the classification according to Stehlin and Schaub, this is not being done, since they presented none. Many of their views are incorporated or discussed below. They leave no doubt, however, as to their agreement with one of the theses of the present paper, namely, that the threefold classification of rodents is outmoded, that the current grouping of the superfamilies is generally unwarranted, and that there has been a tremendous amount of parallelism within the order.

Lavocat (1951) again has reverted to the Tullberg dual classification, but has added a third group, the "Atypognathes", being largely Wood's Protrogomorpha or Simpson's Aplodontoidea. While he presents only a partial classification of the order, it is definitely an advance in separating the "Hystricognathes" into "Orthohystricognathes: Rongeurs sud-américains" and "Parahystricognathes: Formes palæarctiques et africaines," and in placing the Theridomyidae and Anomaluridae together in a subdivision of the "Sciurognathes," the "Parasciurognathes" characterized by an enlarged infra-orbital foramen.

Ellerman (Ellerman and Morrison-Scott, 1951) seems to have decided that any attempt at superfamilial classification is hopeless. He states (p. 457) that "Simpson divides the Order into three 'Suborders', Sciuromorpha, Myomorpha, and Hystricomorpha, which are not here adopted as they are held to be indefinable." He then quotes the part of Simpson's classification dealing with Palæarctic and Indian rodents, but apparently makes no further mention of any categories larger than the family.

Wood and Patterson (in press), in a review of the early South American rodents, erected

a new subordinal name (suggested by Simpson in 1950), the Caviomorpha, for the South American "Hystricomorpha" and raise objections to Lavocat's emphasis on the structure of the angle of the mandible in classification.

Schaub (1953*a*) has again discussed the classification of rodents, with special emphasis on the "Hystricomorpha". Here he re-emphasizes his earlier objections to the "Sciuromorpha" and "Myomorpha." While justifiably objecting to the use of the characters of the infraorbital foramen and masseter muscle as the basic criterion for rodent classification, he apparently feels that the dental characters can be so used without danger, and that therefore all rodents with five-crested molars come from a common source, the Theridomyidae. He considers that those South American rodents that have other than five crests represent deviations from this pattern, and, while agreeing with Wood (1950) that the South American rodents were derived from North American ones, he believes that the ancestral stock was not the Paramyidae but a pentalophate form (presumably theridomyid) that has not yet been found in North America. As does the present paper, Wood (1950) incorporated conclusions as to the relationships of the Paramyidae, based on still-unpublished material. Wood and Patterson (in press) showed to their satisfaction that the five-crested tooth developed in South America, and that the fifth crest was *not* homologous to the fifth crest of the Theridomyidae (i.e., not a mesoloph and mesolophid). The early South American rodents seem to be basically four-crested. Wood, in his still unpublished monograph on the Paramyidae, is showing that four-crested teeth have been developed within the family Paramyidae and that in at least one case, such an incipient four-crested form has an enlarged infraorbital foramen. For these reasons, it is believed that Schaub is accepting dental parallelisms as indications of relationship, where he does not accept parallelisms in other structures.

In this paper, Schaub proposes a new suborder, the Pentalophodonta, to include all forms with teeth derived from a five-crested ancestry. This he divides into two infraorders. The first is the Palaeotrogomorpha, including the superfamilies Theridomyoidea (families Pseudosciuridae and Theridomyidae), Hystricoidea (family Hystricidae) and Castoroidea (family Castoridae), together with a series of families *incertae sedis*, namely, Thryonomyidae, Eupetauridae, Petromyidae, Bathyergidae, Spalacidae and Rhizomyidae. The second infraorder, the Nototrogomorpha, are the South American hystricomorphs, equivalent to the suborder Caviomorpha given below.

An additional important paper by Schaub (1953*b*, perhaps published in 1954) emphasizes the necessity for deriving all the varying types of rodents from an ancestor that had cheek-tooth patterns that could have led to those of their descendants. This may seem obvious, but it is important to keep in mind in analyzing rodent relationships. Schaub's point of view in this paper and that of the present author seem very close. Schaub indicates that the resemblance between such South American rodents as the Chinchillidae and the European theridomyid *Archaecomys* must be parallelisms. He continues to argue for the break-up of the Myomorpha and Sciuromorpha, in which the present paper in part follows him. He stresses the primitive nature of the tooth pattern of the Sciuridae and of *Paramys* and its relatives. The major point of difference from the present paper lies in the importance of the early members of the Paramyidae, a point on which my own opinions have changed as a result of an extensive but still incomplete monograph of the family. Moreover, whether or not the Lower Eocene members of the Paramyidae are more or less primitive in their tooth structure than are the Oligocene squirrels, they are certainly more primitive in their skull structure.

While these are by no means all the classifications that have been proposed, they are perhaps the most important and critical ones for an understanding of rodent classification.

PROPOSED CLASSIFICATION

After what has been said above, it might appear to be a waste of time to try to put the families or superfamilies together into any subordinal arrangement. To a certain extent this is true. Simpson has recently suggested (in litt., dated March 22, 1954) that perhaps

there are no suborders of rodents, and that the superfamilies are all of independent origin. This is perhaps an unnecessarily strong revulsion from the current concepts, and there certainly are some cases where two or more superfamilies have closer relationships to each other than to other superfamilies. For example, the several superfamilies here placed in the Caviomorpha are universally agreed to be related to each other. Whether it is justifiable to put all rodents in suborders, or whether some superfamilies should be left without subordinal allocation might be a matter of argument. An attempt to reach the first of these alternatives is presented here.

Another problem is the names to be used for the suborders. Since Brandt's three suborders have been so highly modified from their classical content, it might seem advisable to coin new names. After considerable hesitation, it has been decided to retain these because they are familiar and because each one still includes the family from which its name was derived. But even more important, it is felt that the next few years will see extensive modifications of the accepted classification of rodents, and there are definite advantages in keeping the number of subordinal names to a minimum until some kind of stability is reached.

For those families whose genera are not well known, where a revision is here being made, or where there are only a few known genera, all genera are listed. For families that are well known, with no changes in content from what is given by Simpson (1945) or with many genera, no listing of genera is considered necessary.

The classification that is proposed for consideration is presented below, with comments where such seem to be appropriate.

ORDER RODENTIA BOWDICH, 1821

SUBORDER SCIUROMORPHA BRANDT 1855

Relatively primitive members of the order, either having the origin of the masseter limited to the ventral surface of the zygoma, or advancing up the anterior face of the arch. Infraorbital foramen of fair size in early forms, squeezed by the migration of the masseter in others, or enlarged in others. Dental formula primitive for the order, being (with only a minor exception) I 1/1, C 0/0, P 2/1, M 3/3. All known forms with tritubercular or quadritubercular cheek teeth are included here, though several groups here included have developed more complicated structures. Microscopic structure of incisor enamel primitively pauciserial, progressively uniserial (Korvenkontio, 1934). This group includes some, but by no means all, of the classical Sciuromorpha, and is equal to all of Wood's (1937) Protrogomorpha plus the Sciuridae.

SUPERFAMILY ISCHYROMYOIDEA WOOD, 1937.—Basically primitive rodents, including the common stock from which the rest of the order has been derived and most of the initial, Eocene radiation. All current authors are in agreement that the rodents here placed without question in this superfamily are closely related. Some (e.g. Simpson, 1945; Wilson, 1949*a*) place all but the Protoptychidae in the Ischyromyidae as subfamilies. This is a matter of minor import, but the amount of structural variation warrants their being considered separate families.

FAMILY PARAMYIDAE MILLER AND GIDLEY, 1918.—Primitive in both zygomasseteric structure and cheek-tooth pattern. Some variations in size of infraorbital foramen, but generally of medium dimensions. Origin of masseter always (except in *Rapamys*) limited to the ventral surface of the zygoma, and cheek teeth always bunodont, but progressively approach a four-crested pattern. Incisor enamel pauciserial. Tympanic bulla generally not co-ossified with the skull. Clearly the ancestral stock of the order, in spite of Stehlin and Schaub's argument (1951) that they are secondarily simplified. Schaub (1953*a*, p. 390) states, of the group here called Ischyromyoidea, that they "are not far removed from the Sciuridae, but no member of this family is so primitive as the *Sciurus* of the European Oligocene." While I am not familiar at first hand with these European forms, Schaub has equally not had first-hand experience with the numerous Lower Eocene paramyids now being reviewed by Wood. *Sciurus feignouzi* and *Sciurus* sp. as figured by Stehlin and Schaub

(1951, Figs. 293–295) are definitely more advanced than most of the undescribed or poorly figured Lower Eocene paramyids. The origin of this family is unknown. Upper Paleocene to Middle Oligocene of North America and Lower to Upper Eocene of Europe. Genera: *Paramys, Leptotomus, Decticadapis, Reithroparamys, Rapamys, Pseudotomus, Ischyrotomus, Plesiarctomys, Manitsha, Pelycomys, Prosciurus,* and *Cedromus.*

Family Sciuravidae Miller and Gidley, 1918.—Primitive in zygomasseteric structure, but cheek teeth bunolophodont, developing four transverse crests. There is never a fifth crest. Incisor enamel pauciserial. Size small. These rodents are a very interesting and probably important group. They were partially reviewed by Wilson (1938*a*, *b*, *c*), but are badly in need of a complete revision, which may well establish them as an important intermediate link in rodent relationships. One of the most interesting genera referred to this family is *Pauromys*. This shows many similarities to the Cricetidae, to which Stehlin and Schaub (1951, p. 336 and 384) have referred it. The presence of P /4, however, would separate it from all other members of that family. If, as seems possible, *Pauromys* is ancestral or nearly ancestral to the cricetids, its familial allocation would depend on whether one preferred a vertical or a horizontal classification. It is here left in the Sciuravidae, because, until additional material is found, it does not seem warranted to carry the Cricetidae back to the Middle Eocene. Derivable from Lower Eocene paramyids. Lower to Upper Eocene of North America. Genera: *Sciuravus, Mysops, Pauromys, Tillomys,* and *Taxymys.*

Family Ischyromyidae Alston, 1876.—Animals the size of *Sciurus* or larger, with four well-developed transverse crests on cheek-teeth. There is never a fifth crest. Completely lophodont, but cusps still distinguishable. Incisor enamel uniserial. Masseter sometimes migrates upward onto anterior face of zygoma. Presumably derived from Upper Eocene paramyids or sciuravids. Little or nothing is known about them beyond what is included in Wood, 1937. Lower to Upper Oligocene of North America. Genera: *Ischyromys* and *Titanotheriomys.*

Family Cylindrodontidae Miller and Gidley, 1918.—Specialized burrowing rodents, with high crowned cheek teeth based on a pattern of four transverse crests. Origin of the masseter limited to ventral surface of the zygoma. These rodents were studied by Burke (1935, 1936, 1938), who was able to work out some of the evolutionary trends within the family, but who did not have adequate material to solve their problems completely. While there is some uncertainty about their origin, they were presumably derived from the Sciuravidae. Upper Eocene to Upper Oligocene of North America, and Oligocene of Asia. Genera: *Pareumys, Cylindrodon, Pseudocylindrodon, Presbymys, Ardynomys, Cyclomylus, Tsaganomys, Pseudotsaganomys,* and *Sespemys.*

Family Protoptychidae Wood, 1937.—Rodents with tremendously inflated auditory bullae and mastoid regions paralleling dpodids or *Dipodomys* in this respect. Temporal muscle reduced and sagittal crest absent. Cheek teeth four crested, high crowned. Tooth pattern presumably derivable from sciuravid ancestry. Significance of skull structure unknown. Upper Eocene of North America. Genus: *Protoptychus*. This genus has been considered to have some special relationships with the Dipodidae or Heteromyidae. While such a connection may have existed with the Dipodidae, it seems exceedingly unlikely with the heteromyids (Wood, 1935*a*, p. 239–40). And, in the case of the jerboas, the most that can be said is that it cannot at present be demonstrated that *Protoptychus* is not related to them. Certainly the skull has developed in a manner similar to that of the dipodids and the cheek teeth are both crested and high crowned. But those of the dipodids are based on five crests, including the mesoloph/mesolophid, and those of *Protoptychus* on four, lacking those crests. Cases are few and far between where a four-crested rodent tooth has been derived from a five-crested one or vice versa. In the Caviomorpha, as discussed below, a five-crested pattern is derived from a four-crested one, but here the fifth crest is not a mesoloph/mesolophid. The most reasonable position for these forms is as a presumably leaping family of the Ischyromyoidea.

?ISCHYROMYOIDEA, incertae sedis.

FAMILY PHIOMYIDAE, NEW FAMILY.—Small rodents with low to medium crowned teeth with well-developed four-crested pattern. Dental formula P /1, M /3; upper teeth unknown. Condition of infraorbital foramen unknown. The genera grouped in this family are some of the most baffling of all the rodents. Neglecting various earlier references, Simpson (1945, p. 82-83) referred them to "cf.? Theridomyidae *incertae sedis*." Schaub (1953*a*, p. 394) lists them as "Theridomyoidea *inc. sedis*." They differ from all theridomyids, however, in the presence of only four transverse crests, agreeing in this respect with the crested ischyromyoids. If the zygomasseteric structure were shown to be ischyromyoid, this allocation would be nearly certain. It is possible that there is a close affinity with some of the other families of the ischyromyoids, but there is no adequate basis for accepting such a relationship at the present time. They are perhaps derivable from the Sciuravidae, but this is still a guess. Oligocene to Miocene of Africa. Genera: *Phiomys*, *Metaphiomys*, *Paraphiomys*, and *Diamantomys*.

SUPERFAMILY APLODONTOIDEA MATTHEW, 1910.—Burrowing rodents with progressively hypsodont teeth and persistently primitive zygomasseteric structure. Tendency to enlarge P 4/4. Characteristically Miocene and Pliocene, though a few representatives are known earlier and later.

FAMILY APLODONTIDAE TROUESSART, 1897.—Cheek teeth progressively hypsodont, with enlarged mesostyles. Upper cheek teeth represent modifications of tritubercular pattern, with large conules and additional crests connecting them. Incisor enamel uniserial. Stock (1935) has indicated that they are presumably derivable from Middle or Upper Eocene paramyids, though the details have not been worked out Upper Eocene to Recent of North America; Lower Pliocene of Asia; perhaps Upper Eocene of Europe. Genera: *Eohaplomys*, *Haplomys*, *Allomys*, *Meniscomys*, *Liodontia*, *Pseudaplodon* and *Aplodontia*, and perhaps *Sciurodon*. Schaub (Stehlin and Schaub, 1951, p. 356) considers *Sciurodon* to be an aplodontid. Although this is such a distinctive genus that this should probably be still considered questionable, such an allocation is surely more reasonable than anything else that has been suggested to date.

FAMILY MYLAGAULIDAE COPE, 1881.—Highly modified burrowing rodents. At least some members of the family bore paired horns on the nasals, and at least some members had none. The significance of these variations is still unknown. P 4/4 are progressively enlarged and exceedingly hypsodont. This may result in the molars being forced out by the premolars, so that in adults there may be two, one, or no molars. P 3/ has been lost. P /4 retains the enlarged mesostyles of the Aplodontidae in earlier mylogaulids. P /4 is elongate antero-posteriorly and lakes tend to elongate in the same way. Stock (1935) and McGrew (1941) have partially traced the phylogeny of this family, and shown that they were presumably derived from Upper Oligocene or Lower Miocene aplodontids. Lower Miocene to Middle Pliocene of North America. Genera: *Promylagaulus*, *Mylagaulodon*, *Mesogaulus*, *Ceratogaulus*, *Mylagaulus* and *Epigaulus*.

SUPERFAMILY SCIUROIDEA GILL, 1872. Rodents that have enlarged the masseter, with a slip extending up in front of the zygoma, compressing the infraorbital foramen to a narrow slit between the muscle and the snout. Cheek teeth typically very close to those of the Paramyidae, but some members of the group have developed more specialized teeth. Schaub (1953*a*, p. 398-399) has separated *Eupetaurus* from the Sciuridae, and placed it as a separate family related to his Palæotrogomorpha (see above, p. 169). While this seems drastic, I have no first-hand feelings about the relationships of this genus.

FAMILY SCIURIDAE GRAY, 1821.—The Sciuridae as listed by Simpson (1945) plus *Protospermophilus*, *Palaearctomys*, *Arctomyoides* and *Paenemarmota*. Same characters as for superfamily. Generally primitive cheek teeth, but xerines, for example, with definitely specialized tooth pattern, though, presumably, derivable from basic sciurid pattern. Incisor enamel uniserial. Oligocene to Recent of Europe; Miocene to Recent of North America; Pleistocene to Recent of Asia; Recent of Africa and South America. Derivable from paramyids, largely by modification of the masseter and infraorbital foramen.

CF. SCIUROMORPHA, *INC. SED.*

SUPERFAMILY CTENODACTYLOIDEA SIMPSON, 1945.

FAMILY CTENODACTYLIDAE ZITTEL, 1893.—This family has many features in common with the Theridomyidae. Lavocat (1951, p. 69–70) has listed these in considerable detail, including the structure of the angle of the mandible and the enlargement of the infraorbital foramen. The cheek teeth, however, seem very clearly to be based on four transverse crests, rather than five. This condition is found in many of the advanced sciuromorphs, and the character of the angle is also sciuromorphine. If Wood's interpretation of the size of the infraorbital foramen of *Rapamys* (Wood, *in mss.*) is correct, the Sciuromorpha also includes forms with this foramen greatly enlarged. The incisor enamel is stated by Korvenkontio (1934) to be multi-serial, differing in this from all other Sciuromorpha. Lavocat (1951), Stehlin and Schaub (1951), and Schaub (1953a) all agree that the ctenodactylids cannot be closely related to the theridomyids. On the basis of these authorities they are placed here. The resemblances to the theridomyids might then be interpreted as meaning that the two families had a common origin from Lower Eocene paramyids, or, and more probably, could merely indicate parallelism. Upper Oligocene—Middle Pliocene of Asia, and Recent of Africa. Genera: *Karakoramys*, *Tataromys*, *Sayimys*, *Ctenodactylus*, *Pectinator*, *Massouteria*, and *Felovia*.

SUBORDER THERIDOMYOMORPHA, NEW SUBORDER

Rodents with enlarged infraorbital foramina, normally transmitting part of the masseter muscle. In the living forms this is the anterior portion of the masseter medialis, and presumably was the same in the fossil forms. The cheek teeth are based on a five-crested pattern in both upper and lower molars, with well-developed mesoloph and mesolophid. This is the pattern that Stehlin and Schaub consider to be the archetype of complex rodent cheek teeth, but which almost certainly has been acquired several times independently, and which does not seem to be ancestral to anything that is less complex. There is no more justification for considering that a five-crested South American rodent is of necesity related to a five-crested European one, when the intermediate sequence cannot be traced in detail, than for assuming that all rodents with a "Sciuromorph" infraorbital foramen are related. In other words, there is no valid basis for such an assumption. The angle of the lower jaw is in the plane of the ascending ramus. As here defined, this is an Old World, and largely Ethiopian, group. It is partially equivalent to Lavocat's "Parasciurognathes" (1951) or to Schaub's Palæotrogomorpha (1953*a*). Eocene to Oligocene of Europe; Miocene to Recent of Africa; perhaps Oligocene of Africa.

SUPERFAMILY THERIDOMYOIDEA LAVOCAT, 1951.—Cheek teeth bunodont to lophodont and brachyodont to extremely hypsodont, but based on five crests, the fifth being the mesoloph/mesolophid. P 3/ lost, leaving cheek teeth P 1/1, M 3/3. Infraorbital foramen large, of "hystricomorph" pattern. Incisor enamel pauciserial or uniserial. Lavocat's association (1951, p. 73) of the Theridomyidae and Pseudosciuridae seems to have solved two of the knottier problems of fossil European rodents. His analysis seems thoroughly convincing, a conclusion with which Schaub (1953*a*, p. 398) agrees.

FAMILY THERIDOMYIDAE ALSTON, 1876.—Cheek teeth lophodont and mesodont to extremely hypsodont. Advanced genera parallel South American rodents in their dental structure. Lavocat (1951) and Stehlin and Schaub (1951) have demonstrated quite clearly that the theridomyids are derivable from *Adelomys* or something very close to it. This genus is included by those authors in the Pseudosciuridae (see below). Lavocat's analysis of the Theridomyidae (1951 p. 68–69) concludes that they cannot be ancestral to the South American hystricomorphs, and do not show any indications of ancestry to the Hystricidae. Wood (1950) and Wood and Patterson (in press) have shown, from the other end, that the Caviomorpha cannot be considered to be descended from the Theridomyidae. Stehlin and Schaub's invaluable monograph (based solely on dental characters) is an attempt to demon-

strate that the theridomyid cheek tooth pattern could be ancestral to that of almost all other rodents that have crested teeth. Whether or not it could (which is presumably beside the question), it quite obviously was not. The paramyid pattern preceded it in time. A series of structural stages from *Paramys* to *Decticadapis* to *Adelomys* to *Theridomys* shows the progressive development of the theridomyid pattern during the Lower and Middle Eocene, as suggested by Schaub (1953*b*). A similar series of stages leads from the paramyids to the more advanced Eocene and Oligocene ischyromyoids. Since in most cases the detailed phylogenies have not yet been worked out, there is no *a priori* reason why the sciuravids, for example, could not be ancestral to just as many later forms as were the theridomyids. In the case of every rodent family whose phylogeny has been worked out in detail, the tooth pattern can be more reasonably followed back to a paramyid than to a theridomyid ancestry. The former is not very far from a typical tuberculo-sectorial ancestor; the latter is. The Theridomyidae were considered by Lavocat (1951) to be quite distinct from most other rodents, and closely related only to the Pseudosciuridae and Anomaluridae. Stehlin and Schaub (1951) and Schaub (1953*a*) disagree strongly with this point of view. I feel impelled to agree with Lavocat, that whatever else may be the relationships of the theridomyids, there are none with the Caviomorpha. Upper Eocene to Middle Oligocene of Europe. Genera: *Theridomys*, *Trechomys*, *Isoptychus*, *Blainvillimys*, *Oltinomys*, *Taeniodus*, *Archaeomys* and *Issiodoromys*.

Family Pseudosciuridae Zittel, 1893.—Cheek teeth brachyodont. Mesoloph and mesolophid of variable size. Lavocat (1951) and Stehlin and Schaub (1951) have shown that *Adelomys* provides a connecting link between the Theridomyidae and Pseudosciuridae, and agree that it should be referred to the Pseudosciuridae. It is also close to the original specimen on which the genus *Decticadapis* was erected. Wood is showing, in his monograph on the Paramyidae, that the sequence from small, lowest Eocene species of *Paramys* to *Decticadapis* to *Adelomys* seems to be a true phylogenetic sequence. Middle Eocene to Middle Oligocene of Europe. Genera: *Adelomys* and *Pseudosciurus*, and *Suevosciurus* if that is not a synonym of *Adelomys*.

SUPERFAMILY ANOMALUROIDEA GILL, 1872.—Scansorial rodents, with lophate cheek teeth bearing four or five crests. Incisor enamel uniserial. Stehlin and Schaub consider these to represent a reduction from the five-crested theridomyid condition. They consider (1951, p. 360–361) that there is evidence for special affinity between the anomalurids and the eomyids. This does not seem very acceptable, in view of the great difference in infraorbital structure of the two, *Anomalurus* being hystricomorph and the eomyids sciuromorph. I have followed Lavocat in placing the Anomaluridae closer to the theridomyids than to anything else. The absence of any recognized fossil record for the anomalurids does not help matters.

Family Anomaluridae Gill, 1872.—Characters same as for superfamily. Recent of Africa. Perhaps derivable, as suggested by Lavocat (1951), directly from the Theridomyidae. Genera: *Anomalurus*, *Idiurus*, and *Zenkerella*.

CF. SCIUROMORPHA OR THERIDOMYOMORPHA *INC. SED.*

Family Pedetidae.—Large, saltatorial rodents with inflated bullae. Cheek teeth P 1/1, M 3/3. As in the case of the Ctenodactylidae, there are numerous similarities between the pedetids and some at least of the theridomyids (Lavocat, 1951, p. 69). These include the structure of the zygomasseteric and infraorbital region; the general shape of the skull; the structure of the palate, including its posterior border and the position of the palatine foramina; and the presence of inflated auditory bullae both in *Pedetes* and *Issiodoromys*. Lavocat believes that the structures of the mandible could have been derived from a theridomyid ancestry as well as anything else. However, he states that the tooth pattern is the reverse of that of *Issiodoromys*, which would eliminate any possibility of close relationship. All specimens and figures of pedetids that I have seen, however, have teeth that are worn until there are only two prisms of enamel, connected on the lingual sides of both upper and lower teeth (Stromer, 1926, pl. 42). Little or nothing can be told from these figures of the original

unworn pattern, except that very possibly there is no hypocone in the upper teeth. Friant (1932, p. 87) seems to have been the only author to discuss unworn pedetid teeth. Her statement that "elles sont formées de deux prismes se terminant chacun par une cuspide" does not help to clarify cusp homologies in this family. Stehlin and Schaub (1951) and Schaub (1953*a*) have not discussed the pedetids. The incisor enamel differs from that of typical sciuromorphs and theridomyomorphs in being multiserial. Other than this, there is no basis for placing the Pedetidae in any of the suborders discussed below, and there is no justification for erecting a new suborder for them. They are therefore left here *faute de mieux*. Miocene to Recent of Africa. Genera: *Pedetes* and *Parapedetes*.

SUBORDER CASTORIMORPHA, NEW SUBORDER

Rodents with the *Masseter lateralis anticus* expanded on the front of the zygoma, as in the Sciuridae, squeezing the infraorbital foramen against the face. A heavy ridge is present between the fossa of this branch of the muscle and the infraorbital foramen. Cheek teeth lophodont, based on a five-crested pattern. Adaptations primarily fossorial. Incisor enamel uniserial. These rodents have long been associated with the Sciuridae and Geomycidea in the Sciuromorpha. At the present time, they appear suddenly in the Lower Oligocene with animals that have already acquired the typical beaver features. There is no valid evidence that their zygomasseteric structures have been acquired in common with those of the Sciuridae, and certain other of their structures, notably cheek-tooth pattern, are widely divergent. It is true that some of the Geomyoidea are as different from the other Myomorphs as they are from the beavers, but at least there are cranial features that tend to unite them with muroids. From the point of view of dental morphology, the beavers could be considered as being derived from some of the Ischyromyoidea, from the Theridomyidae, from some of the Myomorpha, from the Caviomorpha, or from the Hystricomorpha. All of these except the Myomorpha and Hystricomorpha are known in sufficiently complex stages early enough in time to be related to the Castorimorpha. However, there are no data to support one of these relationships in preference to another. Presumably the beavers are ultimately derived from the Paramyidae, but just how or where is completely unknown. Of the seven suborders proposed here, this one is the most problematical. It seems very possible that there is a sufficiently close relationship between the beavers and one of the others to justify their being grouped together. But at present there is no evidence to support one allocation rather than another. Certainly there is no phylogenetic basis for considering them close to the Sciuridae. Schaub agrees with this point of view, stating that "The Castoroidea form a superfamily which must entirely be separated from the Sciuroidea . . ." (1953*a* p. 398). He places them with the Theridomyoidea and Hystricoidea in his Infraorder Palaeotrogomorpha. Since the Theridomyoidea are here widely separated from the Hystricoidea, it is impossible to follow him in his allocation of the beavers without choosing between these two groups. While I have long suspected that there might be a special relationship between the Castoridae and Hystricidae, or Castoridae and Caviomorpha, there does not seem to be any convincing phylogenetic basis for associating them, and this suborder is established in the hopes that it will soon be shown to be superfluous. The rodents included in this suborder are clearly related. Whether they should be two families, or two subfamilies of a single family is a matter of minor import. Certainly *Eutypomys* (Wood, 1937) is far more distinct from the castorids than any subdivisions of the latter are from each other.

SUPERFAMILY CASTOROIDEA GILL, 1872.—Synonymous with the suborder.

Family Castoridae Gray, 1821.—Castorimorphs with relatively simple, crested molars, progressively becoming very hypsodont. Cheek tooth formula P 2-1/1, M 3/3. Lower Oligocene to Recent of North America; Upper Oligocene to Recent of Europe; Upper Miocene to Recent of Asia. This family is in process of extensive revision by Stout, but, until his paper appears, the genera given by Simpson (1945) plus *Paradipoides* may be taken as a complete listing.

Family Eutypomyidae Miller and Gidley, 1918.—Castorimorphs with very highly

complex cheek teeth. Basically similar to the castorids in skull pattern. Rather peculiar adaptations as indicated by structure of the pes (Wood, 1937, p. 229–230). Stehlin and Schaub state that "*Eutypomys* ist bekanntlich von Matthew bloss versuchweise an die Biber angeschlossen worden. Verschiedene Details in der Struktur der Unterkiefermolaren forderten einen Vergleich mit analagen Bildungen bie *Eomys*, *Pauromys* und Cricetodontinae heraus. Sie schliessen eine Ableitung vom Trechomysplane aus und Nötigen uns, den Anschluss dieses merkwürdingen Genus anderswo zu suchen" (1951, p. 360). Schaub merely states that "The Eutypomyidae have been removed from the Castoroidea" (Schaub, 1953*a*, p. 398). In spite of this weight of authority, there are such strong resemblances in skull structure between *Eutypomys* and the beavers that it seems necessary to leave them in the same superfamily (Wood, 1937). Middle to Upper Oligocene of North America. Only known genus: *Eutypomys*.

SUBORDER MYOMORPHA BRANDT, 1855

Mouse-to-rat-sized rodents, with tubercular to lophate cheek teeth. Cheek teeth P 2-0/1-0, M 2-3/2-3. Frequent tendency toward saltation, which is correlated with inflation of the auditory bullae. Zygomasseteric structure modified by expansion of masseter in front of zygoma ("sciuromorph" pattern), expansion through the zygoma ("hystricomorph" pattern) or both ("myomorph" pattern). Incisor enamel always uniserial. There are obvious problems in connection with the assemblage of these forms in a single suborder. Each of the superfamilies contains a basic group of families that are surely related. But there are other forms that are of problematic allocation in most instances. Thus there are problems in connection with all superfamilies that cannot clearly be resolved at the present time. Nevertheless, there are so many basic similarities among the group that it seems worth while grouping them, if for no other reason than to prompt a more detailed analysis of these similarities. If all the forms here called myomorphs are correctly associated, it is obvious that they must have split off from the Ischyromyoidea before the individual groups developed their modified masseters, which are thus characters of secondary taxonomic value. The origin of this suborder can only be guessed at. There are suggestions of relationship to some sciuravids particularly *Pauromys* (see above, p. 171). But these need much clarification.

SUPERFAMILY MUROIDEA MILLER AND GIDLEY, 1918.—Myomorphs with the masseter expanded both through the infraorbital foramen and in front of the zygoma. Cheek teeth reduced to M 3-2/3-2, with premolars lost by the first appearance of the group in the Lower Oligocene. Body form scampering, fossorial or occasionally saltatorial.

Family Cricetidae Rochebrune, 1883.—Molar pattern based on five crests in both upper and lower teeth, differing from that of the theridomyids in the shortness of the mesoloph/mesolophid. Low crowned to very high crowned. Scampering, fossorial, saltatorial, or partly aquatic. Lower Oligocene to Recent of Europe and North America; Middle Oligocene to Recent of Asia; Pliocene to Recent of South America; Pleistocene to Recent of Madagascar; Recent of Africa. Genera: Those given by Simpson (1945, p. 83–88) plus *Cimarronomys*, *Myocricetodon*, *Pliotomodon*, *Neocometes*, *Typhlomys* and *Platacanthomys*. This is one of the most abundant and diversified of all the rodent families. There is relatively little disagreement as to the content of the family, though there has been considerable as to the subfamilial arrangement of various genera. Ellerman (1940) has argued that the distinction of the murids from the cricetids is no greater than that of the microtines, and that they both are subfamilies of cricetids. This is a matter of personal opinion, and is of no fundamental importance. Everyone agrees that these three groups of rodents are closely related. This is a sufficient accomplishment so that all rodent taxonomists should be happy. In a recent paper (Schaub and Zapfe, 1953), Schaub has described a new Miocene genus, *Neocometes*, which is very close to *Typhlomys* and *Platacanthomys*. As he indicates the teeth of *Neocometes* are similar both to gliroid and cricetid teeth. This leads to three possibilities: that these forms are gliroids paralleling the cricetids; that they are cricetids paralleling the gliroids; or that they represent a distinct family, probably of cricetid origin,

developing gliroid tendencies. Schaub considers that they are a tribe Platacanthomyini of the Cricetinae. On his authority this group is placed in the Cricetidae. If this is done, it helps to tie in the Nesomyinae with the cricetids, since Ellerman (1949, p. 128) has pointed out the convergence between *Gymnuromys* and the platacanthomyines.

Family Muridae Gray, 1821.—Cheek teeth 3/3 or 2/2. Tooth pattern based on rounded cusps, arranged in transverse rows, but derived by modification of cricetid pattern. Low to medium high crowned. Scampering, occasionally fossorial or semi-aquatic. Pliocene to Recent of Europe and Asia; Pleistocene to Recent of Australia; Recent of entire world. The rodents of this family are generally considered to be of quite recent origin. They appear to be the most rapidly evolving of all the rodents with the possible exception of the subfamily Microtinae of the Cricetidae. The murids are clearly descended from the cricetids, as indicated by Schaub (1938). Ellerman (1949, p. 130, 134) suggests that the murids were arboreal forms living in southeast Asia before the Pliocene, and that they may have had a long, unrecorded history. This is possible, but Schaub's evidence seems to be opposed to it, and it is more probable that they represent a Miocene offshoot of the cricetids. *Palustrimus*, described by Wood (1935*b*) from the Miocene of Oregon, has many similarities to the Muridae. It is known, however, only from a single tooth. It would therefore be unwarranted to draw any phylogenetic or paleogeographic conclusions from it until more material is found. Basically, the Muridae are of southeast Asian distribution. Their evolutionary center is certainly in southeast Asia and the East Indies. They are one of the two non-aquatic placental groups to have invaded Australia before the arrival of man; the other being the bats. The murids clearly arrived by island-hopping from New Guinea. Tate (1951, p. 220) has shown that there must have been at least three periods of invasion, the earliest probably in the early Pleistocene.

MUROIDEA, INC. SED.—Most authors consider that the Spalacidae and Rhizomyidae are somewhat distantly related to the cricetids and murids. Stehlin and Schaub (1951) and Schaub (1953*a*, *b*) deny the correctness of this allocation on the ground that the tooth pattern of these two families is derived from that of *Theridomys*, whereas that of the cricetids was not. As indicated above, I cannot agree with these authors on the fundamental significance of resemblances of later forms to the theridomyids. There are enough cases where independent development of this pattern can be almost positively demonstrated so that it should be suspected in this case. Moreover, in view of the absence of early fossil rhizomyids and spalacids, there does not seem to be any compelling reason at present to be certain that their tooth pattern was not derived from that of early cricetids. However, Stehlin and Schaub (1951, p. 96) state that the cheek teeth of these forms are P 4/4, M 1-2/1-2 and not M 1-3/1-3. This peculiarity suggests that a separate superfamilial status for these two families might well be warranted.

Family Spalacidae Gray, 1821.—Fossorial rodents. Masseter with very little spread on face in front of zygoma, but part of *Masseter medialis anticus* passing through infraorbital foramen. Upper Pliocene to Recent of Europe; Recent of Asia and Africa. Genera: *Pliospalax*, *Prospalax* and *Spalax*.

Family Rhizomyidae Miller and Gidley, 1918.—Burrowing rodents. Masseter and infraorbital foramen basically muroid, cheek teeth based primarily on four transverse crests. Upper Oligocene of Europe; Upper Miocene to Recent of Asia; Pleistocene to Recent of Africa. Genera as given by Simpson (1945, p. 88).

SUPERFAMILY GEOMYOIDEA WEBER, 1904.—Myomorphs in which the *Masseter lateralis anticus* has spread up on the face in front of the zygoma, squeezing the infraorbital foramen against the face. Never any sharp separation between infraorbital foramen and masseteric fossa. Living forms possess fur-lined cheek pouches outside the mouth. Two very diverse cheek tooth patterns: lophate and five crested in the Eomyidae, and bunodont and progressively bilophate in the Heteromyidae and Geomyidae. Cheek teeth always P 1/1, M 3/3, except in *Diplolophus*, a genus of doubtful relationships, where the formula is reduced to 3/3, presumably M 3/3, and in an undescribed eomyid where there are two upper premolars. Scampering, fossorial or saltatorial.

FAMILY EOMYIDAE DEPÉRET AND DOUXAMI, 1902.—Cheek teeth five crested, with mesocone and mesoconid generally extending into a mesoloph or mesolophid. Infraorbital foramen geomyoid. Skull with many similarities to primitive heteromyids and cricetids (Wilson, 1949*b*, p. 42–48). Skeleton unknown. Wilson discussed the relationships of the eomyids at considerable length, and finally considered them the most primitive family of the Geomyoidea, although he felt "that the Eomyidae should perhaps be viewed as a relatively primitive group of rodents which departed from the same branch of the Aplodontoidea [here called Ischyromyoidea] that gave rise to the heteromyids and muroids—all three being about equally remote from one another, but the heteromyids and ecmyids less so; all of closer affinity to one another than to the sciurids and castorids." (Wilson, 1949*b*, p. 48). The most striking difference between the eomyids and the heteromyids is in the tooth pattern. *Ritteneria* (Stehlin and Schaub, 1951, fig. 190, 506), however, is very suggestive of the heteromyids and primitive geomyids in this respect, and adds considerable weight to the allocation of the eomyids to this superfamily. Stehlin and Schaub (1951, p. 295) consider *Kansasimys*, from the Pliocene of Kansas, to be an eomyid. This is an interesting suggestion, which, while far from proven, is certainly more reasonable than most other allocations for that peculiar genus. Upper Eocene to Miocene of Europe; Upper Eocene to Middle Oligocene and perhaps Pliocene of North America. Genera: *Eomys*, *Rhodanomys*, *Omegodus*, *Ligerimys*, *Ritteneria*, *Pseudotheridiomys*, *Protadjidaumo*, *Adjidaumo*, *Paradjidaumo*, and perhaps *Kansasimys*.

FAMILY HETEROMYIDAE ALLEN AND CHAPMAN, 1893.—Small to minute scampering and saltatorial rodents. Cheek teeth based on bilophodont pattern. Teeth four-cusped, with only a few forms becoming highly hypsodont. Lower Oligocene to Recent of North America, Recent of northern South America. Genera as given by Simpson (1945, p. 81) except for correction of *Cupidinomys* to *Cupidinimus* and addition of *Prodipodomys*.

FAMILY GEOMYIDAE GILL, 1872.—Fossorial geomyoids. Cheek teeth based on same pattern as in heteromyids, but evolve (especially in the Geomyinae) at a faster rate, so that they are usually one geologic period ahead of the heteromyids. Teeth rapidly become hypsodont and ever-growing, with enamel tending to be reduced to an anterior plate in the upper teeth and a posterior plate in the lowers. Lower Miocene to Recent of North America. Genera as given by Simpson (1945, p. 80), plus *Pliogeomys*, *Plesiosaccomys*, *Nerterogeomys* and *Parageomys*.

GEOMYOIDEA INC. SED.—Diplolophus.—Cheek teeth of heteromyid or geomyid pattern, but reduced to 3/3. Some very suggestive similarities to murids. Clearly an offshoot of the other members of the group, but of uncertain significance. Perhaps ancestral to *Palustrimus*? Skull and skeleton unknown. Middle Oligocene of western North America. *Griphomys.*—This genus, from the Upper Eocene of California, is perhaps a very primitive geomyoid and perhaps an aberrant ischyromyoid of some sort, but was very tentatively considered to be the former by Wilson (1940). Unfortunately, it is sufficiently distinctive to add little to our knowledge of geomyoid phylogeny. It might suggest, however, the way in which the peculiar heteromyid-geomyid tooth pattern originated.

SUPERFAMILY DIPODOIDEA WEBER, 1904.—Infraorbital foramen large, transmitting branch of masseter. Bullae generally inflated. Cheek teeth brachyodont to hypsodont. Pattern originally quite similar to that of primitive cricetids, progressively evolving in its own direction. P 4/ often present. Generally saltatorial. There seems to be universal agreement that the dipodids and zapodids are related. There is less agreement as to what they are related to. Miller and Gidley (1918) considered them the basis for their fourth major group. Simpson (1945) includes them in the Myomorpha, as does Ellerman (1940). Stehlin and Schaub (1951, p. 368–369) suggest that they be left with the Muroidea until something better could be done. Schaub (1951, p. 209) would remove them, since "Les 'Myomorpha' sont devenus, comme les 'Sciuromorpha', un sous-ordre en train de se dissoudre. Les Gliroidea sont complètement isolés; les Dipodoidea le sont un peu moins." If *Simimys* is a zapodid, as seems to be true, that family was present in the Upper Eocene. This suggests the probability that either the dipodoids and muroids split immediately

after they separated from the ancestral stock, or that the two have nothing in common, phylogenetically. The presence of P 4/ in many dipodoids shows that the group cannot be descended from any known muroid. While it is too early to reach any firm conclusion, the dipodoids are here left in the Myomorpha, at least until we know more of where, when, and from what, they arose.

FAMILY ZAPODIDAE COUES, 1875.—Scampering to saltatorial rodents. Cheek teeth reduced to P 1-0/0, M 3/3, low to medium crowned. Pattern basically similar to that of primitive cricetids, but cusps united in a somewhat different manner. Infraorbital foramen of medium size. Eocene to Recent of North America; Oligocene to Recent of Eurasia. Genera: *Simimys*, *Plesiosminthus*, *Schaubeumys*, *Sicista*, *Heterosminthus*, *Pliozapus*, *Zapus*, *Napaeozapus* and *Eozapus*. The reference of *Simimys* and *Schaubeumys* to this family is on the authority of Schaub (Stehlin and Schaub, 1951). This is a rather significant addition to our knowledge of the family because, if *Simimys* is ancestral to the Zapodidae, this group goes back into the Upper Eocene, which rather strongly suggests that the dipodoids (or perhaps the zapodids) have an origin from the ischyromyoids independent of that of the other Myomorpha. This family is a natural group. *Sicista* and its fossil relatives are separable from the other genera as a distinct, and more primitive, subfamily.

FAMILY DIPODIDAE WATERHOUSE, 1842.—Highly saltatorial rodents with inflated bullae. Three median metatarsals fused in all living genera to form a cannon bone. Cheek teeth reduced to P 1-0/0, M 3/3, and are hypsodont in all modern forms. Tooth pattern superficially similar to that of microtines. Early genera brachydont to mesodont. Infraorbital foramen large. Very possibly derived from Zapodidae. Pliocene to Recent of Asia; Pleistocene to Recent of Europe and Northern Africa. Genera: those listed by Simpson (1945, p. 93).

CF. MYOMORPHA, *INC. SED.*

SUPERFAMILY GLIROIDEA SIMPSON, 1945.—The dormice are a compact group, but quite isolated. Simpson considered them to be a distinct superfamily of the Myomorpha. Stehlin and Schaub, while agreeing that they represent a distinct superfamily, feel that there is no basis for associating the dormice with the myomorphs, but rather that "die Gliroidea einen selbstandigen Zweig der Simplicidentaten bilden." (*op. cit.* p. 367). Schaub (1951, p. 208) says the same thing: "Les Gliroidea, taxés jusqu'ici comme 'Myomorphes', n'ont, dans la structure de leurs molaires, aucun rapport avec les Muroidea et forment une superfamille isolée et indépendante." And again, "the separation of the Gliroidea from the Muroidea is so clear that the two superfamilies cannot be assembled into the same suborder" (Schaub, 1953*a*, p. 389). I am completely unfamiliar with the details of dormouse structure or evolution from first-hand investigations. In view of the weight of Schaub's authority, it is probably foolhardy to leave them anywhere near the myomorphs. This suborder, however, is being extensively revised here, and it is possible that the gliroids may belong in it as revised. The gliroids are as close to the muroids in tooth structure as the heteromyids are, which is not saying very much. As indicated above (p. 167), it is very possible that it is futile to try to establish acceptable suborders for most of the rodents, and that the superfamily is the largest subordinal unit that will be useful for most of the order. The gliroids are one of the most prominent candidates for an independent position. There is a difference of opinion as to the number of families of dormice. Simpson (1945, p. 91–92) gives the two families here recognized plus Platacanthomyidae. Ellerman (1949, p. 2 and 132) considers the Seleviniidae as a subfamily of the Gliridae, as he also does with the Platacanthomyidae. There has been general agreement that the three are closely related to each other and not to anything else. In none of the papers just cited has Schaub specifically discussed the content of the Gliroidea. However, in a recent paper (Schaub and Zapfe, 1953) Schaub transfers the Platacanthomyidae to the Cricetidae, in which he is here followed, as indicated above.

FAMILY GLIRIDAE THOMAS, 1897.—Myomorph type of zygomasseteric structure, except that only a small part of the masseter passes through the infraorbital foramen. Cheek

teeth 4/4, with low crowns and a peculiar pattern of parallel crests. Size small. Origin unknown. Middle Oligocene to Recent of Europe; Recent of Asia and Africa. Genera given by Simpson (1945, p. 92) plus *Gliravus* and *Peridyromys*.

FAMILY SELEVENIIDAE ARGYROPULO AND VINOGRADOV, 1939.—Cheek teeth small, and reduced to 3/3, with relatively simple pattern. Enlarged bullae. Saltatorial. Recent of Asia. Only genus: *Selevinia*.

SUBORDER CAVIOMORPHA, WOOD AND PATTERSON (IN PRESS)

Rodents with greatly enlarged infraorbital foramen, through which passes a large part of the *Masseter medialis*, to arise from the face in front of the zygoma. Infraorbital foramen often approaches orbit in size. Cheek teeth always P 1/1, M 3/3. Cheek teeth developed from a four-crested ancestral pattern, never with a mesoloph or mesolophid. (In the cases where there are five crests, Wood and Patterson, in press, are showing that the fifth is never homologous to the mesoloph and mesolophid in other rodents, being an independent development within the Caviomorpha, to which they have given the names neoloph and neolophid.) Incisor enamel multiserial. These rodents have been separated as a distinct suborder almost exclusively on the basis of phylogenetic and paleogeographic grounds. The present suborder is an exact synonym of Schaub's Infraorder Nototrogomorpha. The caviomorphs are a group of rodent families particularly characteristic of South America. It has been generally agreed (Simpson, 1945; Wood, 1950; etc.) that these families evolved in isolation in South America, and, in the Pliocene, invaded North America where they are now represented by a few forms. The ancestral stock of this group suddenly appears in the Oligocene of South America (Wood, 1949, 1950; Wood and Patterson, in press), presumably having invaded South America around the end of the Eocene by island-hopping from North America. The suborder then carried out its adaptive radiation within South America. As has frequently been pointed out (Wood, 1950; Labocat, 1951; Wood and Patterson, in press), there are no known Old World rodents in the right stages of evolution at this time to be ancestral to the Caviomorpha, in addition to the difficult problem of transporting rodents across the Atlantic. This suborder presumably (both on morphologic and geographic grounds) was derived from North American members of the Paramyidae, particularly such a form as *Rapamys*. Schaub (1953*a*, p. 390–394) has discussed Wood's interpretation of the phylogeny of these forms. He agrees with Wood in his paleogeographic ideas, and that the ancestor of the South American rodents reached there from North America. He believes (p. 393) that the ancestors of the South American rodents must have reached there by the early Eocene, Paleocene, or even earlier. In view of the entire absence of rodents from the pre-Oligocene deposits of South America and of the almost complete absence of Paleocene (to say nothing of earlier) rodents anywhere in the world this seems an improbable assumption, and Wood and Patterson (in press), continue to seek the origin of the Caviomorpha in the Paramyidae. The resemblances to the caviomorphs of the forms here included in the Hystricomorpha are surely parallelisms, rather than due to any kind of trans-Atlantic transportation. All or nearly all students of rodents are now agreed on this point. Middle Oligocene to Recent of South America, Pleistocene to Recent of West Indies, and Pleistocene to Recent of North America.

SUPERFAMILY OCTODONTOIDEA SIMPSON, 1945.—Small, generally rather primitive caviomorphs. The earliest forms apparently are very close to being ancestral to all the later caviomorphs, with the possible exception of the erethizontoids.

FAMILY OCTODONITAE WATERHOUSE, 1839.—Low to high crowned teeth. Locomotion scampering in the more primitive forms, fossorial in more specialized ones. This family has been enlarged by the inclusion of part of the group of rodents called Acaremyinae by most authors (e.g., Simpson, 1945, or Schaub, 1953) or Acaremyidae by Wood (1949). Wood and Patterson (in press) have pointed out that *Platypittamys* and *Octodon* are very similar in the post-cranial skeleton. *Platypittamys* is closer than any other known form to the ancestry of the Caviomorpha, and hence to the ancestry of the Chinchilloidea and Cavioidea, but is even closer to *Octodon*, and so must be placed in this family. Middle Oligocene to

Recent of South America; Pleistocene of the West Indies. Genera: Octodontidae of Simpson, 1945, plus *Platypittamys*, *Acaremys* and *Sciamys*.

Family Echimyidae Miller and Gidley, 1918.—Close to octodontids, but molars have deeper anterior and posterior fossettes and fossettids, more oblique crests, a marked tendency for the reduction and loss of the metalophid. Except in the earliest genus, P 4/4 are lost, the deciduous teeth being preserved throughout the animal's life. This is discussed at some length by Wood and Patterson (in press). Middle Oligocene to Recent of South America; Pleistocene to Recent of West Indies and Central America. Genera: those listed by Simpson (1945) and in addition, *Protacaremys* and some species formerly referred to *Acaremys* (as *A. minutus*).

Family Ctenomyidae Tate, 1935.—This family presents few problems. It apparently is a late-Tertiary derivative of the octodontids. Most authors seem to accept its validity without question. Pliocene to Recent of South America. Genera: *Actenomys*, *Eucelophorus*, *Xenodontomys*, *Megactenomys* and *Ctenomys*.

Family Abrocomidae Miller and Gidley, 1918.—This is another family presenting no taxonomic problems, which had a history similar to that of the Ctenomyidae. Pliocene to Recent of South America. Genera: *Protabrocoma* and *Abrocoma*.

SUPERFAMILY CHINCHILLOIDEA KRAGLIEVICH, 1940.—This superfamily has been allocated a variety of forms. Wood and Patterson, however, in their review of the Deseadan rodents (in press) point out a number of rather strong similarities between the capromyids and the chinchillids, and they have therefore grouped them in this superfamily. Premolars apparently based on three crests in both upper and lowers.

Family Chinchillidae Bennet, 1833.—Pattern-bearing portion of cheek teeth progressively restricted to a small area near the crown, so that pattern is quickly lost. Bullae enlarged. Locomotion at least partially saltatorial. Middle Oligocene to Recent of South America. Chinchillidae of authors.

Family Capromyidae Smith, 1842.—Chinchilloids in which the pattern-bearing portion of the crown of the cheek teeth lengthened proportionately to the increase in the height of the crowns. Scampering, burrowing, or semiaquatic locomotion. Bullae of normal size. Wood and Patterson (in press) have demonstrated that *Cephalomys* belongs with the capromyids and helps to tie this family to the chinchillids. This leads to the elimination of the family Cephalomyidae. Even if there were any question as to the status of this family, the teeth of *Cephalomys* show that it cannot belong to the Cavioidea, where Simpson placed them. Whether the hutias and the coypus should be a single family, as indicated by Simpson, or two related families as given by Schaub, is a minor matter and of relatively minor import. The two groups assuredly are closer to each other than to anything else. Middle Oligocene to Recent of South America. Genera: Capromyidae of Simpson (1945) plus *Cephalomys* and *Litodontomys*.

SUPERFAMILY CAVIOIDEA KRAGLIEVICH, 1930.—High crowned cheek teeth, based on a four-crested pattern that soon becomes reduced to two prisms of enamel, connected near the buccal side of the upper teeth and the lingual side of the lowers. Often accessory crests have developed. Cursorial or sub-cursorial. Often large, including the largest known rodents. The content of this superfamily is left as given by Simpson (1945, p. 94–97), except for the elimination of the Cephalomyidae as explained above. Schaub's superfamily Dinomyoidea (1953*a*, p. 399) is surely composite, the chinchillas having nothing to do with the other families he places there. There is a real separation, however, between the Eocardiidae, Caviidae and Hydrochoeridae, which are all that Schaub leaves in the Cavioidea, and the Dinomyidae, Heptaxodontidae and Dasyproctidae, which he places in the Dinomyoidea. However, I do not believe that this separation is as fundamental as that between the Cavioidea and the other caviomorphs. In other words, there seems to have been an eocardiid stock in the Oligocene that gave rise to all the other forms here placed in the Cavioidea. The variants of taxonomic expression seems to be less important than the fundamental fact of a relationship.

Family Eocardiidae Ameghino, 1891.—Medium to high crowned cheek teeth, always

with smaller ephemeral mesofossettids. These rodents represent an initial radiation of the cavioids, giving a primitive stage in the development of this superfamily, not directly ancestral to the later radiations. Considerable confusion has existed in regard to the correct allocation of *Luantus*, due at least partly to the fact that the syntypes of *L. initialis* are referable to distinct families (Wood and Patterson, in press). Middle Oligocene to Lower Miocene of South America. Genera: *Asteromys*, *Luantus*, *Eocardia*, *Schistomys* and *Phanomys*, but not *Archaeocardia*.

Family Caviidae Waterhouse, 1839.—Small, cursorial cavioids, with extremely hypsodont cheek teeth, but always relatively simple. The content and relationships of this family seem to be generally agreed upon. Derivable from eocardiids. Pliocene to Recent of South America. Caviidae of authors.

Family Hydrochoeridae Gill, 1872.—Large, cursorial cavioids. Cheek teeth high crowned to ever-growing, with some to many accessory crests. Derivable from Caviidae. These forms are sometimes included in the Caviidae as a subfamily, but the distinctions are great enough to warrant familial separation. Pliocene to Recent of South America; Pleistocene of North America; Recent of Central America. Genera: as listed by Simpson (1945, p. 95).

Family Dinomyidae Alston, 1876.—Cheek teeth exceedingly hypsodont, with extra laminae, derivable from eocardiid ancestry. Body heavy. As discussed above, there is a clear distinction between Schaub's Dinomyoidea and Cavioidea. It would be perfectly reasonable to separate them at a level between the family and superfamily, if such a taxonomic entity were in existence. As far as these groups are concerned, my differences from Schaub are apparently purely in the form of the taxonomy, and mean nothing. The same is true of the content of the Dinomyidae. Here I have chosen to follow Kraglievich (1926 and 1940) and Simpson (1945) in leaving the Dinomyidae as a monogeneric family rather than including with it the related forms here listed under Heptaxodontidae. Again, this is a very minor point. Recent of South America. Genus: *Dinomys*.

Family Heptaxodontidae Miller and Gidley, 1918.—Cheek teeth progressively hypsodont and made up of a series of laminae. Large size, including the largest known rodent. The separation of these forms from *Dinomys* is discussed above. Miocene to Pliocene of South America; Pleistocene to Recent (?) of West Indies. Genera as given by Simpson (1945, p. 96).

Family Dasyproctidae Smith, 1842.—Cheek teeth with clearly developed fifth crests (neoloph/neolophid) and high crowned. Digits of pes reduced to 3. Body form cursorial. The separation of *Cuniculus* from the Dasyproctidae, as proposed by various authors (Miller and Gidley, 1918; Ellerman, 1940; Stehlin and Schaub, 1951; Schaub, 1953*a*) seems to be warranted both by the extreme peculiarities of the skull of *Cuniculus*, and by the rather striking differences in the cheek tooth pattern. Most authors consider the dasyproctids to be what are here called Cavioidea. Schaub lists the family as *inc. sedis* within the South American complex. While its exact position may be uncertain, it perhaps more probably belongs here than in any other specified place. Recent of South America. Genera: *Dasyprocta* and *Myoprocta*.

Family Cuniculidae Miller and Gidley, 1918.—Cheek teeth high crowned, generally five-crested, but lower molars four crested. Very peculiar modification of malar and maxillary. The absence of fossils makes it impossible to trace the phylogenetic history of either this family or its predecessor. Until more of their history is known, they should probably be considered distinct families. Schaub places this family in his Dinomyoidea, where I would place both this family and the Dasyproctidae. Recent of South and Central America. Genera: *Cuniculus* and *Stictomys*.

SUPERFAMILY ERETHIZONTOIDEA SIMPSON, 1945.—This superfamily is quite isolated. As pointed out above, all members of the Acaremyinae have been placed elsewhere. Wood (1949, p. 52) and Wood and Patterson (in press) consider that the Deseadan caviomorphs are all very closely related, except for the erethizontids, which were already distinct. How long before the Deseadan they were separate is obviously unknown, but they

surely originated as an offshoot of the basic caviomorph stock, after it had arrived in South America.

Family Erethizontidae Thomas, 1897.—The New World porcupines. Semi-arboreal to arboreal forms. Cheek teeth crested, but generally mesodont to subhypsodont. Upper cheek teeth bear four to five crests. Wood and Patterson have concluded that this fifth crest is a neomorph, in process of development in South America. Stehlin and Schaub consider it strong evidence for the theridomyid ancestry of the Caviomorpha. *Chaetomys* is considered to belong here rather than in the Echimyidae, as given by Stehlin and Schaub (1951, p. 369). Middle Oligocene to Recent of South America; Upper Pliocene to Recent of North America. Genera: *Eosteiromys*, *Steiromys*, *Neosteiromys*, *Erethizon*, *Coendou*, *Echinoprocta*, and *Chaetomys* and *Parasteiromys* if it is valid.

SUBORDER HYSTRICOMORPHA BRANDT, 1855

Rodents with a greatly enlarged infraorbital foramen, through which the *Masseter medialis* passes from its origin on the face. Infraorbital foramen perhaps somewhat smaller than in Caviomorpha. Cheek teeth P 1/1, M 3/3. Mesoloph and mesolophid may be present in the cheek teeth. Incisor enamel multiserial. Old World. This definition does not adequately separate the Hystricomorpha from the Caviomorpha. Perhaps no definition can do so. However, it is very clear (Wood, 1949, 1940; Wood and Patterson, in press) that the Caviomorpha have been a natural unit since the early Oligocene, and that they can have had no relationships with the Hystricomorpha, as here defined, since the Eocene. There is no evidence whatever that any hystricomorph had developed that early, or that any ever reached the New World. Schaub (1953*a*) derives both the Old World and the New World forms from the Theridomyidae, and only unites them taxonomically in that they have such a common source. He still separated them as infraorders. Lavocat (1951) does not believe that the forms here placed in the Hystricomorpha could have been derived from the theridomyids. Certainly such an ancestry has not yet been proven, though equally certainly some Old World Eocene rodents must have been ancestral to these forms. After removing all the rodent families that can be shown *not* to be related to the Old World porcupines from the Hystricomorpha, very little remains. The separation of the Caviomorpha (Schaub's Nototrogomorpha) seems to have met with practically unanimous approval. The basis for the separation of the Theridomyomorpha has been outlined in considerable detail. As already indicated, there is much merit in Schaub's placing the beavers with the Hystricoidea. I have not followed him, partly because it is not clear whether he would prefer to place the Castoroidea with the Hystricoidea or with the Theridomyoidea, assuming the last two to be separated as they are here. Furthermore, there is no direct evidence of connection between the Castoroidea and the Hystricoidea, and if one thing should be obvious about rodent classification, it is that it is dangerous to consider two forms to be related until there is positive evidence in favor. Although it is very possible that there is a close connection between these two superfamilies, such a drastic change should perhaps wait for a little stronger support. The Thryonomyidae and Petromuridae may or may not belong here. There is no evidence that would justify their removal, and little to validate their presence here. But since both Simpson and Schaub group them with the Old World porcupines, it would perhaps not be advisable to shift them without some reason.

SUPERFAMILY HYSTRICOIDEA GILL, 1872.—The Old World porcupines are an isolated group, which both Simpson and Schaub agree are the only members of this superfamily.

Family Hystricidae Burnett, 1830.—Quilled forms. Cheek teeth based on a modified five-crested pattern, perhaps related to that of the theridomyrids, perhaps not. Nasal and frontal regions inflated and arched. Oligocene to Recent of Europe; Middle Pliocene to Recent of Asia; Recent of Africa. Genera: The Hystricidae of authors.

SUPERFAMILY THRYONOMYOIDEA NEW SUPERFAMILY.—The placing of the Petromuridae and Thryonomyidae together in a single superfamily is based partly on

morphologic similarity, without any paleontologic support. Moreover, there are many obvious similarities to the Octodontidae and Echimyidae, respectively. These are so great that formerly the African genera were placed in the South American families. This is still done sometimes, the latest example being Ellerman, Morrison-Scott and Hayman (1953, p. 237–239), who consider the Thryonomyinae, Petromurinae and Echimyinae to be subfamilies of the Octodontidae. As has been pointed out elsewhere on numerous occasions (e.g., Wood, 1950), the chances of African rodents reaching South America to give rise to the Caviomorpha are exceedingly remote. The chances of two South American rodents reaching Africa to give rise to the Petromuridae and Thryonomyidae would likewise be exceedingly slim, especially in view of the direction of the prevailing ocean currents. The placing of these African forms in the Caviomorpha is morphologically justified, but paleogeographically impossible. Therefore the similarities between the forms of the two continents must be considered to be parallelisms rather than indications of relationship. However, since the two South American families belong in the same superfamily, perhaps their African parallels are similarly related. The geographic distribution of the thryonomyids and petromurids favors this. Their known characters do not rule out such a relationship.

Family Thryonomyidae Pocock, 1922.—Cheek teeth consist of dP 4/4, M 1-3/1-3, with the permanent premolars suppressed as in the Echimyidae (Friant, 1945). Teeth high crowned, with pattern formed, apparently, of only three crests in the molars and upper premolar and four in the lower premolar. Stehlin and Schaub (1951) argue that this is simplification, which it may be. But in view of the almost complete absence of a fossil record of the family, any attempt to discuss its phylogeny involves a large series of pure assumptions. They could be descended by simplification from five-crested ancestors; they might have come directly from four-crested ones such as some of the Ischyromyoidea; or they may have arisen independently from tuberculate ancestors within the Paramyidae. Pliocene of Asia; Pleistocene to Recent of Africa. Genera: *Paraulacodus* and *Thryonomys*.

Family Petromuridae new name?—Hystricomorph type of masseter. Rat-like in build and habits. Cheek teeth 4/4, all apparently based on a four-crested pattern (Stehlin and Schaub, 1951, figs. 146 and 453). The discussion of origin and relationships given for the Thryonomyidae applies equally well here. The family name Petromyidae, proposed by Tullberg (1899), is based on *Petromys*. The genus was originally described as *Petromus* (Smith, 1831), but he emended it to *Petromys* in 1834 (fide Roberts, 1951, p. 353). I have not been able to see Smith's 1834 paper, so have no way to determine whether this was a correction of a misprint, and hence allowable under the International Rules, or a change of some other sort that would not be allowable. Ellerman, Morrison-Scott and Hayman (1953, p. 239) do not specifically settle this point, although they state that "We do not agree with Simpson . . . who suggests that *Petromus* in the original publication 'may well have been a misprint correctable under the Rules'." Since Smith's 1834 paper was presumably available to them, I have followed their decision as to the correct generic name, but am proposing a new family name, since they use the subfamilial name, Petromurinae. If *Petromus* is the correct spelling, the family name has to be changed to Petromuridae. Pleistocene to Recent of Africa. Only genus: *Petromus*.

SUBORDER BATHYERGOMORPHA ROBERTS, 1951?

This term may have been used previously by someone else, but I have found no record of it. Rodents with small infraorbital foramen not transmitting any part of masseter. The masseter, however, is quite complex and highly differentiated. The *Masseter medialis anticus* has expanded upward inside the zygoma, and arises from the upper part of the median wall of the orbit and the *Masseter lateralis superficialis* has moved partly onto the anterior face of the zygoma. If the structure of the masseter means anything, it indicates that these rodents could not have been descended from anything in which the masseter was more advanced than in the Ischyromyoidea. Incisor enamel multiserial. There have been two general tendencies in connection with these forms—to isolate them, as is being done here, or to place them with the Hystricidae. Tullberg (1899) and Miller and Gidley

(1918) isolated them. Roberts (1951) placed them in a separate suborder, the Bathyergomorpha, with no indication as to whether this was the initial use of this term. Simpson (1945, p. 99) listed them as ?Hystricomorpha *incertae sedis*. Schaub (1953*a*, p. 395) called them Palaeotrogomorpha *inc. sedis*, and states (p. 399) that "The Bathyergidae are so highly specialized that closer affinities are entirely unknown." The best guess, perhaps, is that these forms separated from the Paramyidae in the early or Middle Eocene, and have had an independent and southern African existence ever since.

SUPERFAMILY BATHYERGOIDEA OSBORN, 1910.—This consists of a single family.

FAMILY BATHYERGIDAE WATERHOUSE, 1841.—Highly specialized burrowing rodents with powerful upper incisors, whose roots are above or behind the molars. Cheek tooth formula varying from 6/6 to 2/2, in part due to retention of deciduous premolars. Cheek teeth hypsodont with simplified pattern, generally reduced to a circle, but sometimes a fold remains. Lower Miocene to Recent of Africa. Genera: *Bathyergoides*, *Gypsorichus*, *Georychus*, *Cryptomys*, *Heliophobius*, *Bathyergus* and *Heterocephalus*.

LITERATURE CITED

BLAINVILLE, H. M. D. DE. 1834. Cours de la faculté des sciences, 1834. *Fide* Palmer, T. S., Index generum mammalium, 1940, p. 780 and Simpson, G. G., 1945.

BRANDT, J. F. 1855. Beiträge zur nähern Kenntniss der Säugethiere Russlands. Mém. Acad. Imp. Sci. St.-Pétersbourg, ser. 6, vol. 9, 375 p.

BURKE, J. J. 1935. *Pseudocylindrodon*, a new rodent genus from the Pipestone Springs Oligocene of Montana. Ann. Carnegie Mus., 25: 1–4.

———. 1936. *Ardynomys* and *Desmatolagus* in the North American Oligocene. Ann. Carnegie Mus., 25: 135–154.

———. 1938. A new cylindrodont rodent from the Oligocene of Montana. Ann. Carnegie Mus., 27: 255–274.

ELLERMAN, J. R. 1940. The Families and Genera of Living Rodents. Vol. I. British Museum (Nat. Hist.), 689 p.

———. 1949. The Families and Genera of Living Rodents. Vol. III, Part 1. British Museum (Nat. Hist.), 210 p.

ELLERMAN, J. R. AND T. C. S. MORRISON-SCOTT. 1951. Checklist of Palaearctic and Indian Mammals, 1758 to 1946. British Museum (Nat. Hist.), 810 p.

FRIANT, M. 1932. Contribution à l'étude de la différenciation des dents jugales chez les mammifères. Essai d'une théorie de la dentition. Thèses presentées à la Faculté des Sciences de Paris, Série A, No. 1376, 132 p.

———. 1945. La formula dentaire des Rongeurs de la famille des Thryonomyidae. Rev. Zool. Bot. Afr., 38: 200–205.

KORVENKONTIO, V. A. 1934. Mikroskopische Untersuchungen an Nagerincisiven, unter hinweis auf die Schmelzstructur der Backenzähne. Histologisch-phyletische Studie. Ann. Zool. Soc.Zool.-Bot. Fennicae Vanamo, 2: 1–274.

KRAGLIEVICH, L. 1926. Los grandes roedores terciarios de la Argentina y sus relaciones con ciertos géneros pleistocenos de las Antillas. An. Mus. Nac. Hist. Nat., Buenos Aires, 34: 121–135.

———. 1940. Los roedores extinguidos del grupo Neoepiblemidae. Obras Geol. Paleont., La Plata, 3: 739–764.

LAVOCAT, R. 1951. Révision de la Faune des mammifères oligocènes d'Auvergne et du Velay. Éditions "Sciences et Avenir", Paris, 153 p.

MATTHEW, W. D. 1910. On the osteology and relationships of *Paramys*, and the affinities of the Ischyromyidae. Bul. Amer. Mus. Nat. Hist., 28: 43–71.

MCGREW, P. O. 1941. The Aplodontoidea. Publ. Field Mus. Nat. Hist., Geol. Ser., 9: 1–30.

MILLER, G. S. AND J. W. GIDLEY. 1918. Synopsis of the supergeneric groups of Rodents. Jour. Wash. Acad. Sci., 8: 431–448.

ROBERTS, A. 1951. The Mammals of South Africa. Central New Agency, South Africa. 700 p.

SCHAUB, S. 1938. Tertiäre und quartäre Murinae. Abh. Schweiz. Pal. Gesell., 61: 1–39.

———. 1951. Review of: H. G. Stehlin et S. Schaub. "Die Trigonodontie der simplicidentaten Nager". Mammalia, 15: 204–210.

———. 1953*a*. Remarks on the Distribution and Classification of the "Hystricomorpha". Verh. Naturf. Ges. Basel., 64: 389–400.

———. 1953*b*. La Trigonodontie des Rongeurs simplicidentés. Ann. de Paleont., 39: 29–57.

SCHAUB, S. AND H. ZAPFE. 1953. Die Fauna der miozänen Spaltenfüllung von Neudorf an der March (ČSR). Simplicidentata. Sitzber. Österr. Akad. Wiss., Math-naturw. Kl. Abt. I, 162: 181–215.

SCHLOSSER, M. 1884. Die Nager des europäischen Tertiärs nebst Betrachtungen über die Organisation und die geschichtliche Entwicklung der Nager überhaupt. Palaeontographica, 31: 1–184.

SIMPSON, G. G. 1945. The principles of classification and a classification of mammals. Bul. Amer. Mus. Nat. Hist., 85: XVI + 350 p.

———. 1950. History of the Fauna of Latin America. Amer. Scientist, 38: 361–389.

SMITH, A. 1831. South African Quart. Jour., I, no. 5.

———. 1834. South African Quart. Jour., II, no. 2, pts. 1–3.

STEHLIN, H. G. AND S. SCHAUB. 1951. Die Trigonodontie der simplicidentaten Nager. Schweiz. Pal. Abh., 67: 1–385.

STOCK, C. 1935. New genus of rodent from the Sespe Eocene. Bul. Geol. Soc. Amer., 46: 61–68.

TATE, G. H. H. 1951. Results of the Archbold Expeditions no. 65. The rodents of Australia and New Guinea. Bul. Amer. Mus. Nat. Hist., 97: 183–430.

TULLBERG, T. 1899. Ueber das System der Nagethiere: eine phylogenetische Studie. Upsala. Akadem. Buchdruck., V + 514 p.

WILSON, R. W. 1938*a*. Review of some rodent genera from the Bridger Eocene. Part I. Amer. Jour. Sci., 35: 123–137.

———. 1938*b*. Review of some rodent genera from the Bridger Eocene. Part II. Amer. Jour. Sci., 35: 207–222.

———. 1938*c*. Review of some rodent genera from the Bridger Eocene. Part III. Amer. Jour. Sci., 35: 297–304.

———. 1940. Two New Eocene Rodents from California. Carnegie Inst. Wash., Publ., 514: 85–95.

———. 1949*a*. Early Tertiary Rodents of North America. Carnegie Inst. Wash., Publ., 584: 67–164.

———. 1949*b*. On Some White River Fossil Rodents. Carnegie Inst. Wash., Publ., 584: 27–50.

WINGE, H. 1924. Pattedyr-Slaegter. Vol. 2. Rodentia, Carnivora, Primates. Copenhagen, H. Hagerups Forlag. 321 p.

WOOD, A. E. 1935*a*. Evolution and relationships of the heteromyid rodents with new forms from the Tertiary of western North America. Ann. Carnegie Mus., 24: 73–262.

———. 1935*b*. Two new rodents from the John Day Miocene. Amer. Jour. Sci., 30: 368–372.

———. 1937. The Mammalian Fauna of the White River Oligocene by W. B. Scott and G. L. Jepsen. Part II. Rodentia. Tr. Amer. Phil. Soc., 28: 157–269.

———. 1949. A new Oligocene rodent genus from Patagonia. Amer. Mus. Novitates, 1435: 1–54.

———. 1950. Porcupines, paleogeography, and parallelism. Evolution, 4: 87–98.

WOOD, A. E. AND B. PATTERSON. In press. The Rodents of the Deseadan Oligocene of

Patagonia and the Beginnings of the South American Rodent Radiation. Chicago Nat. Hist. Museum.

ZITTEL, K. A. VON. 1893. Handbuch der Palaeontologie. Abt. I. Palaeozoologie. Bd. IV. Vertebrata (Mammalia). Munich. R. Oldenbourg, XI + 799 p.

Biology Department, Amherst College, Amherst, Massachusetts. Received July 24, 1954.

HISTOLOGY AND CYTOCHEMISTRY OF SKIN GLAND AREAS IN THE CARIBOU, *RANGIFER*

BY W. B. QUAY

The microscopic structure and glandular cytochemistry of three specialized cutaneous areas in the caribou form the subject of this report. These are the tarsal gland area, the interdigital gland areas and the preorbital pocket. Their location and gross structure may be seen in Plate I. These structures have been shown to vary in their presence and structure among artiodactyls, and have been most recently reviewed by Schaffer (1940). There is still much, however, that is unknown concerning them, particularly regarding seasonal and sexual variation and microscopic structure and chemistry of the glands. It is hoped that this report will help fill these deficiencies for the caribou, and provide significant information for behavioristic and phylogenic studies as well as for comparative glandular cytology and cytochemistry.

I am very grateful to Ralph S. Palmer for obtaining and providing the skin samples upon which this study is based.

Financial support for publication was provided by funds derived from income on the endowment of the Horace H. Rackham School of Graduate Studies, University of Michigan.

MATERIALS AND METHODS

This study is based upon skin samples from an adult male and an adult female, both shot at Anaktuvik Pass, Brooks Range, Alaska on April 3, 1950. The skin samples were fixed in a formalin-alcohol mixture and were later stored in 70 per cent alcohol. Blocks of tissue, the locations of which are indicated in Plate I, were cut from the samples, washed, dehydrated through a series of ethanol solutions to benzene, and embedded in paraffin. Serial sections 10 microns in thickness were treated by the following techniques. (1) Ehrlich's acid hematoxylin and eosin Y (Bensley and Bensley, 1938). (2) Taenzer-Unna acid orcein method for elastic fibers (Lillie, 1948. The orcein, dissolved in 70 per cent ethanol was used at room temperature. Azure II (Nat. Aniline Lot 11199) (1:1000 distilled water) was used as counterstain. (3) Mallory's phosphotungstic acid hematoxylin (Lillie, 1948), with mordanting in saturated aqueous mercuric chloride at 57°C. for 3 hours. (4) Periodic acid leuco-fuchsin (Lillie, 1948); A. without previous digestion and B. digestion for one hour at 37 C. with 1 per cent diastase (animal) in buffered neutral saline solution (Lillie, 1948) prior to coating slides with 1 per cent nitrocellulose. (5) Long Ziehl-Neelsen method for acid fast lipofuscins (Pearse, 1953). (6) Sudan black B (Nat. Aniline, Cert. No. NZb-2) for lipids (Pearse, 1953) was used at room temperature for 13 hours. (7) Heidenhain's modification of Mallory's connective tissue stain (Azan) (Bensley and Bensley, 1938). (8) Chrome alum hematoxylin method for lipofuscin (Pearse, 1953). (9) Perl's method for ferric

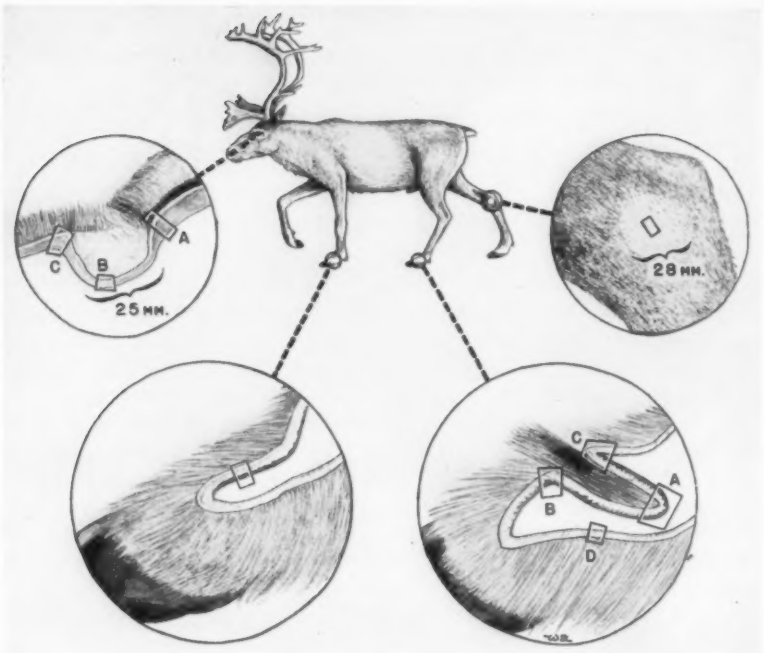


PLATE I

The location of the glandular areas discussed in this report. The areas of tissue removed for sectioning are outlined in the inserts and are lettered (A, B, C, D) when there is more than one in each area.

Upper Left: The preorbital pocket. The insert shows the pocket in vertical longitudinal section and indicates its length (25 mm.).

Upper Right: The tarsal gland area. The insert is a surface view of the area with the hair shaved off. The approximate width (28 mm.) of the area in the female is indicated.

Lower Left: The forefoot interdigital gland. The insert shows the interdigital skin and hair in vertical section. The dark zone at the base of the skin is the apocrine gland layer.

Lower Right: The hind foot interdigital gland. The insert shows the interdigital skin and hair in vertical section. The dark zone at the base of the skin is the apocrine gland layer.

iron (Pearse, 1953) without counterstain. (10) Turnbull blue method for ferrous iron (Pearse, 1953) using a 2½-hour treatment with ammonium sulfide:water—1:3 solution and a 15-minute treatment with freshly prepared mixture of equal parts of 20 per cent potassium ferricyanide and 1 per cent hydrochloric acid; without counterstain. (11) Hueck method for distinguishing melanins from lipofuscins (Pearse, 1953). (12) Alizarin red method for calcium (Pearse, 1953) (Alizarin red S (Alizarin mono sodium sulfonate) Nat. Aniline, Lot 7666). (13) Schmorl method for lipofuscin (Pearse, 1953) without counterstain. (14) Performic acid (Pearse) Schiff method for lipids containing unsaturated bonds (Pearse, 1953). (15) Rogers, Pappenheimer, and Goetsch method for nerve endings (Lillie, 1948) preceded

by the following treatments: (a) xylene, absolute ethanol, hydration through ethanol solutions to water, (b) two days in Bouin's fluid, (c) dehydration through ethanol solutions to absolute ethanol, (d) 10 minutes in 1 per cent nitrocellulose in equal parts of ether and absolute ethanol. (16) Ammoniacal silver reaction (Pearse, 1953) using a 5 per cent chromic acid oxidation for one hour and treatment with hexamine silver solution at 37°C. for three hours. (17) Bensley and Gersh modification of the Millon reaction (Pearse, 1953) employed at room temperature for $3\frac{1}{2}$ hours.

RESULTS

Tarsal gland.—The tarsal gland is an area of unusually glandular skin on the medial side of the hock or ankle (Pl. I). The skin in this area is thickened and bears paler, longer, and stiffer hairs than does the skin of adjacent areas. The gross appearance of the tarsal gland in *Rangifer* has been described in most detail by Caton (1877). It has been described also by Zietzschmann (1903), Pocock (1910), and Jacobi (1931). The tarsal skin samples used in my study show a pronounced sexual difference in both area and thickness of the glandular skin. Since the glandular area is not separated or delimited from the less glandular area, it is not possible to measure it precisely. However, Caton also indicated that this white-haired area is largest in the female. In Plate II it can be seen that the thickness of the skin in the center of the glandular area is much greater in the female than in the male. When the skin samples are examined grossly, it is noted that in the unmodified areas adjacent to the tarsal gland the skin is about 2 mm. thick, in the center of the tarsal gland of the male about 3 mm. thick, and in the center of the glandular area of the female $4\frac{1}{2}$ to 5 mm. thick. Measurements of the size and thickness of the area in more specimens of both sexes, at different ages, and at different seasons are needed before the sexual difference in the size of the glandular area can be proven. Such measurements may show a correlation of increased glandular activity with sexual activity or some seasonal behavior.

Tempel (1896) and Zietzschmann (1903) have given general and brief descriptions of the histological structure of the tarsal gland. Both noted that enlargement of both the sebaceous and the sudoriferous glands occurs in the tarsal gland area, the sebaceous glands and the hair follicles into which they secrete forming a superficial layer and the coiled tubules of the sudoriferous or sweat glands a deeper layer. Zietzschmann further noted that epidermis, dermis, and subcutis are thickened in the area, that elastic fibers are abundant in the dermis, particularly in its more superficial portion, that the sebaceous glands are surrounded by muscle bundles, and that there are numerous large blood vessels and nerves in the subcutis.

In the tarsal glands that I examined, the epidermis may be slightly thickened, but it is certainly not markedly thickened (Plate II). The stratum germinativum is usually but three cells thick and forms the major part of the epidermis. The increased skin thickness is caused almost solely by increase in the thickness of the dermis. And this increase is the result of the increased amount of sebaceous and sudoriferous glandular tissue in the layer.

The dermis may be divided into two zones, a superficial zone containing hair follicles and their associated sebaceous glands and arrector pili muscles and a deep zone containing primarily coiled tubules of the sudoriferous glands. These zones are approximately equal in thickness in the female, but in the male the deep zone is thinner than the superficial and both are thinner than their counterparts in the female. The connective tissue of the superficial zone is especially rich in elastic fibers and capillaries and is loose and cellular. Where the superficial and deep zones meet, there is a layer of abundant small blood vessels and nerves. The connective tissue of the deep zone is of a delicate fibro-elastic type. Bounding the lower surface of the deep zone, and passing gradually into the subcutis, is a thick layer of dense fibro-elastic connective tissue. Along the deeper part of this connective tissue there is a zone of large blood vessels and nerves.

In the superficial zone of the dermis the structures of particular interest are the sebaceous glands and the arrector pili smooth muscles. These structures in the male are enlarged, but they still show the arrangement typical of them generally in unmodified mammalian

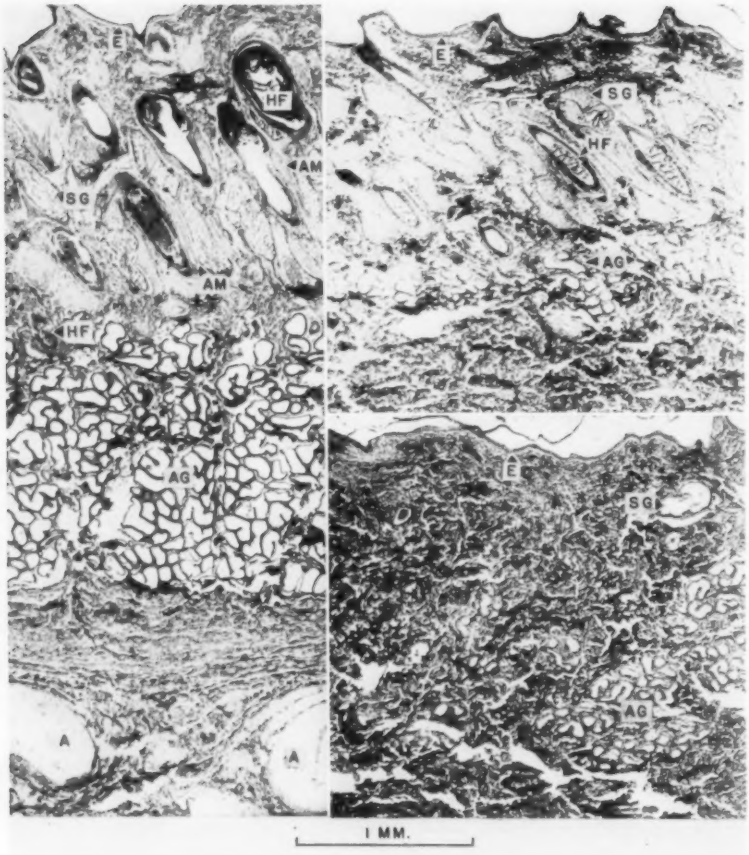


PLATE II

LEFT: Vertical section through the middle of the tarsal gland area of the female.

UPPER RIGHT: Vertical section through the middle of the tarsal gland area of the male.

LOWER RIGHT: Vertical section through the fundus of the preorbital pocket (area B in insert, upper left, Plate I).

Compare the amounts of apocrine gland tissue in the male and female tarsal gland areas and note the density of the connective tissue and the scarcity of glandular tissue in the preorbital pocket. All are stained with phosphotungstic acid hematoxylin and are photographed to the same scale. A—arteries. AG—apocrine gland tubules. AM—arrector pili smooth muscle bundles. E—epidermis. HF—hair follicles. SG—sebaceous glands.

skin. The sebaceous glands are lobulated and each lies next to and secretes into the side of the associated hair follicle. The hair follicles pass into the dermis diagonally, so that one side may be thought of as being above the opposite side. It is on the lower side of the follicles that the sebaceous glands are located. Here also are the arrector pili muscles, each of which is a compact bundle of smooth muscle fibers, serving to both erect the hair and

force secretion from the sebaceous glands. Each arrector pili muscle extends from the connective tissue just beneath the epidermis to the connective tissue ensheathing the basal part of the hair follicle. In the female the arrector muscles are about 1.7 mm. long and about 0.17 mm. in maximum diameter. The hair follicles in the female tarsal gland area are greater in diameter, more irregular in shape, and contain more layers of cornified cells than those in the male. The sebaceous glands and arrector muscles are larger, more compact, and more irregular in arrangement. Many of the cells in the enlarged sebaceous glands of the female are unilocular, retaining a distinct cell membrane and a slightly pyknotic nucleus at the periphery. Only a few such cells are found in the glands of the male, most of whose cells in an equivalent stage of maturation are multilocular.

Since the tissue blocks were treated with ethanol and benzene before embedding, most of the lipids are dissolved out of the sebaceous glands. The vacuoles in the sebaceous cells are empty. However, in the cytoplasm of these cells there remain distinct bodies that are colored black by Sudan black, a stain that selectively colors lipids. From their size, shape and staining with Sudan black, the bodies appear to be mitochondria. In the most peripheral or basal cells with only minute vacuoles, the bodies are usually delicate filaments up to 5 microns long and 0.2 to 0.3 microns in diameter. They can be more or less parallel with each other or they can be irregularly arranged. In sebaceous cells with larger vacuoles, the bodies become shorter and more irregular in shape, in the form of rods, clubs and spheres. The rod-like form is the most common. Large rods measure 3 microns in length and 0.4 microns in diameter; most are about 0.8 microns long and 0.2 to 0.3 microns in diameter. In sebaceous cells containing still larger vacuoles the sudanophilic bodies are usually granules 0.2 to 0.3 microns in diameter. Unfortunately, the thickness of the tissue sections is too great to allow a detailed examination of the relations of these bodies to other cell constituents.

Besides clear vacuoles and black mitochondria in the cytoplasm of the sebaceous cells there is also a faintly granular gray background in slides colored with Sudan black. The most exposed areas of sebum at the gland orifices and in the hair follicles are dark gray to black.

The sudoriferous glands empty their secretions on the surface of the epidermis next to the hair follicles. Next to the opening of each follicle and on the side toward which the hair is inclined, there is usually a funnel-like opening, about 30 microns in diameter at the top and 10 microns in diameter at the bottom. This is the orifice of a sudoriferous gland duct. Each duct leads into the dermis close to and parallel with the associated hair follicle. When it reaches the associated sebaceous gland it passes to one side over it and then downward along its side. It then passes over the side of or through the associated arrector pili muscle. In the connective tissue just beneath the basal bulb of the hair follicle it dilates abruptly into a coiled secretory tubule. Throughout its course the gland duct has an outside diameter of about 10 microns and is a tube lined with two layers of squamous cells, the inner of which is the more flattened.

The secretory tubules have an inside diameter of 35 to 75 microns and are lined with a simple cuboidal epithelium. In the majority of the tubules in both male and female the epithelial cells are low cuboidal and contain little cytoplasm. Nevertheless, in both sexes, short segments of the tubules have high columnar cells that show an apocrine type of secretory activity. From the tips of each of these cells a bleb of secretion is sent into the lumen of the tubule. Most of the secretion blebs found in the lumina of the tubules are still connected by a cytoplasmic strand to their cells of origin.

The cytoplasm of the higher epithelial cells contains granules that stain characteristically. In the tips of the cells fine granular material is colored pink by eosin, brown by orcein, and gray by Sudan black. Throughout the cytoplasm there are larger granules that are colored pink by eosin; similar or identical granules are colored brown or black by Sudan black, blue by chrome hematoxylin, and brown or blue by orcein and Azure II. In the cytoplasm of most epithelial cells, and especially in those that hold much secretory material, there are many globules that are colored deep red to reddish purple by periodic

acid leuco-fuchsin (PAS). These may contain glycogen since they stain in this way. However, due to faulty technique, diastase-treated control sections for glycogen were lost during processing. In the secretion blebs also there are many of these globules. In the apical cytoplasm and in the secretion blebs there are globules that are colored black or dark gray by the ammoniacal silver reaction, indicating the formation of aldehyde groups. Some globules in the blebs are colored gray by Sudan black, some blue by chrome hematoxylin, some brown by orcein, and a few orange or pale red by the Azan technique. Tests for ferric and ferrous iron are negative in the sudoriferous glands, but positive reactions occur in the same sections at sites of parasitic influence on the tissues.

On the outer surface of the secretory tubules there is a single layer of myoepithelial cells, which is bounded externally by a thick basement membrane. The myoepithelial cells are spindle-shaped and run parallel to one another, forming long spirals around the tubules. These cells probably serve to force secretion from the tubules. The myoepithelium is colored dark brown by Sudan black, pale pink by the PAS technique, and red by the Long Ziehl-Neelsen technique. This last reaction is in contrast with the morphologically similar smooth muscle cells of the arrector pili muscles and of the arterial walls, since in these latter two places the cells are colored pale pink by the Long Ziehl-Neelsen method.

The basement membrane is colored pink by eosin and by PAS, dark brown by orcein, and blue by the Azan technique.

Interdigital glands.—The interdigital glands are located in the dorsal interdigital skin. In the hind foot the skin in this area forms a glandular sac, but in the forefoot there is little or no indication of such a structure (Pl. I). Gross descriptions of the interdigital glands in *Rangifer* have been provided by Caton (1877), Tempel (1897), Pocock (1910), Oksala (1927), and Jacobi (1931). Accurate descriptions of the more prominent histological characteristics have been given by Tempel (1897) and Oksala (1927). My account is concerned primarily with facts not covered by these authors.

Hind foot interdigital gland.—The basic histology of the hind foot interdigital gland is the same as that described for the tarsal gland. The features that distinguish it are: (1) lack of any detectable sexual differences, (2) thicker epidermis, (3) more complexly branching sebaceous glands, and (4) markedly different apocrine secretory cytology and cytochemistry.

The results of coloring the sebaceous glands with Sudan black are the same as those reported for the tarsal gland, and sudanophilic bodies which may be mitochondria are abundant.

The secretory cells of the apocrine glands are nearly all columnar in shape, with a basal nucleus and a large amount of apical cytoplasm. This suggests that most of the cells here are in a different stage of the secretory cycle than that observed in the great majority of tarsal apocrine cells (compare Plates II and III). However, at least a few cells typifying each of the stages in the secretory cycle may be found in both tarsal and interdigital glands.

Comparisons of the cytology and cytochemistry of the apocrine cells of the hind foot interdigital glands with that of the tarsal gland apocrine cells show both similarities and striking differences. With regard to the cytoplasm of the apocrine cells, there are two characteristics that are common to both gland areas and a third characteristic that is possibly shared by both. These are: (1) fine eosinophilic, orceinophilic, and slightly sudanophilic granules that are especially numerous at the extreme apex, (2) globules and masses coloring deep red with PAS, which are especially abundant in cells with much stored secretory material, and (3) basophilic masses, rods and globules that are colored blue by Azure II and chrome hematoxylin, which are especially numerous in the middle of each cell just over the nucleus. The chemical nature of the fine apical granules is not apparent. The PAS-positive globules contain glycogen, at least in the hind foot interdigital gland, since successful diastase pretreatment resulted in their complete loss. The basophilic masses in the mid region of the cytoplasm of practically all of the columnar cells often show an orientation perpendicular to the axis of the cell (Middle, Plate IV). These bodies probably contain protein, and possibly are mitochondria that have been distorted by the techniques used.

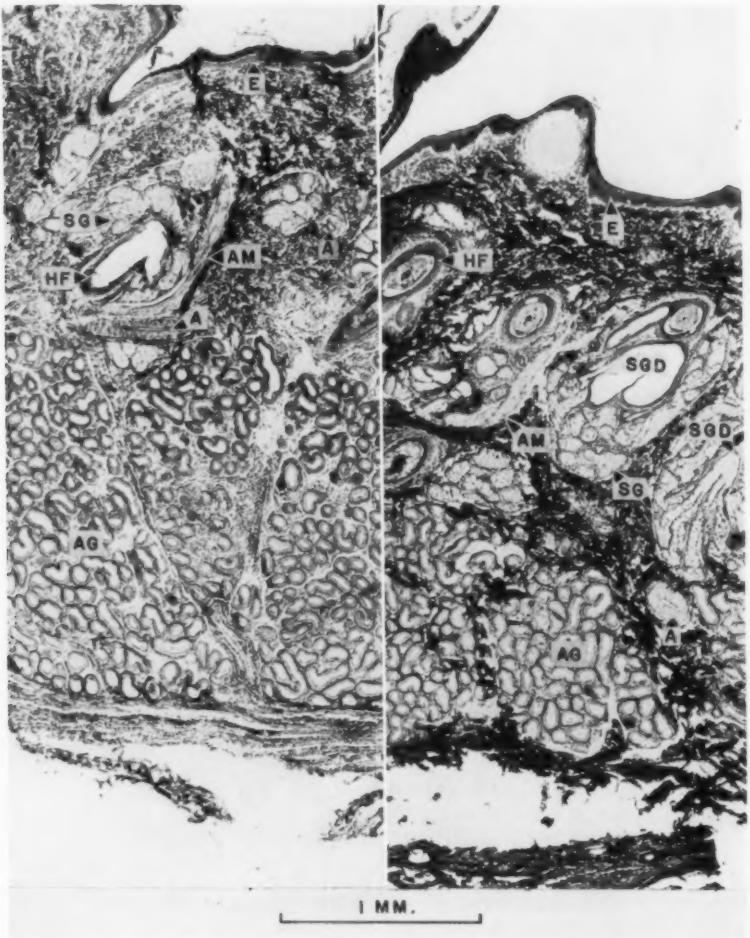


PLATE III

Vertical sections through the skin at the bottom of the hind foot interdigital gland (area A in insert, lower right, Plate I).

LEFT: Female. RIGHT: Male.

Sexual differences suggested here are but local variations and are not significant. Both are stained with phosphotungstic acid hematoxylin and are photographed to the same scale. A—arteries. AG—apocrine gland tubules. AM—arrector pili smooth muscle bundles. E—epidermis. HF—hair follicles. SG—sebaceous glands. SGD—sebaceous gland ducts.

A striking feature in the cytoplasm of practically all hind foot interdigital apocrine cells and in *none* of the tarsal gland apocrine cells is the presence of large yellow to golden brown granules and masses, which are concentrated in the cytoplasm around the nucleus. This material is not a carotenoid since it is insoluble in fat solvents and its staining reac-

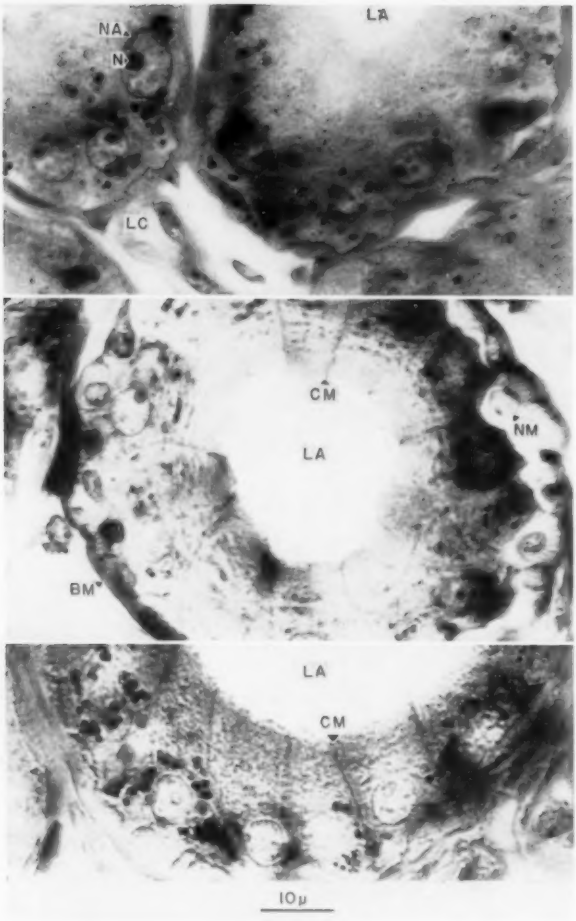


PLATE IV

Cross-sectioned apocrine secretory tubules in the fundus of the female hind foot interdigital gland to show characteristic cytology and staining reactions.

Upper: Long Ziehl-Neelsen technique for acid fast lipofuscin (photographed with a green filter). Note the large darkly staining lipofuscin bodies in the perinuclear cytoplasm.

Middle: Taenzer-Unna orcein technique with Azure II counterstain. In the cytoplasm of the apocrine cells note particularly: (1) fine granular orceinophilic material at the apexes of the cells, especially at lower left, (2) large azurophilic (basophilic) transversely oriented bodies in the middle area of the cytoplasm, especially in cells at left and top, and (3) large, azurophilic (basophilic) lipofuscin bodies, particularly in cells at right. The myoepithelial cells (cross-cut) are unusually swollen here and show their fibrillar cytoplasmic structure.

Lower: Colored with Sudan black B without previous extraction with pyridine. In the cytoplasm of the apocrine cells note: (1) the weak to moderate sudanophilia of small granules in the cytoplasm and (2) the intense sudanophilia of the large lipofuscin bodies around the nuclei.

BM—basement membrane. CM—cell membrane. LA—lumen of apocrine secretory tubules. LC—lumen of capillary. N—nucleolus. NA—nuclear membrane of apocrine cell nucleus. NM—nuclear membrane of myoepithelial cell.

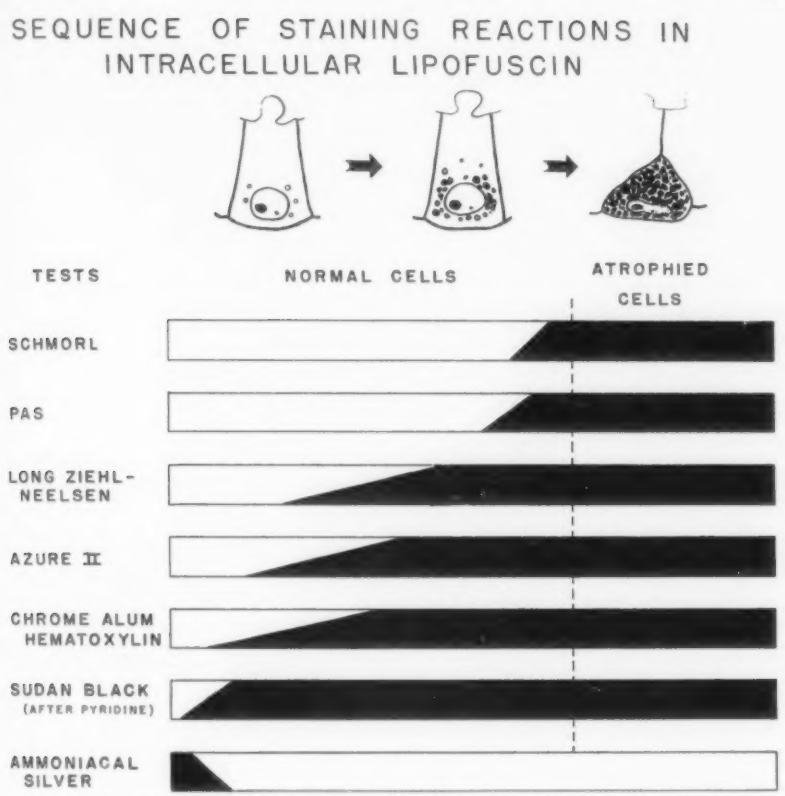


FIG. 1.—Graphic summary of the sequence of staining reactions observed in intracellular lipofuscin bodies in the fundus of the hind foot interdigital gland. This is based upon direct visual inspection of many tubules and cells in different glands and areas. Estimates were made of the fractions of lipofuscin bodies that were not colored, partially colored, and practically entirely colored by each test. The fraction of the lipofuscin granules that reacts positively with a particular test is indicated in black on the bars. However, this graph does not intend to represent the correct ratio of normal to atrophied cells nor of the relative amounts of lipofuscin in each cell type.

tions are not typical for melanin. It is positive with Heuck's method to distinguish lipofuscins from melanine. It is also unstained by PFAS. Its other staining reactions, shown in Figure 1, are those of a ceroid lipofuscin (cf. Pearse, 1953). The development of the lipofuscin bodies and the changes in their staining reactions may be followed in the apocrine cells (Fig. 1). The lipofuscin accumulates in the cytoplasm of the apocrine cells without forming part of the secretion itself, at least not in granular or concentrated form. As more of the lipofuscin accumulates, it forms larger, more darkly colored, and more numerous masses in the cytoplasm around the nucleus. The cell finally atrophies. The end result is a dense ovoid mass of lipofuscin at the base of the epithelial layer. The sequence of staining reactions shown in Figure 1 for the apocrine cell lipofuscin is similar in most respects to the sequence of reactions presented by Pearse (1953) to show the transformation by oxida-

tion of lipid to lipofuscin. Thus, it appears that the golden brown lipofuscin pigment is formed by oxidation of lipids containing aldehydes and that the progressive accumulation of this pigment leads to the degeneration of the cell. Why this should occur in the apocrine cells of the interdigital glands and not those of the tarsal gland is not known, but it certainly demonstrates a fundamental difference in the activity of the two glandular areas.

In the apical cytoplasm of the interdigital apocrine cells there are very few of the other materials reported for the cytoplasm of the tarsal gland apocrine cells. This includes the larger, eosinophilic, basophilic and aldehydic granules and globules. In the secretion blebs there is no material staining with chrome hematoxylin and only scant sudanophilia. But there is a general pale brown coloring by orcein and a pale pink by eosin and a few globules coloring black with the ammoniacal silver reaction. In some tubules in most sections of the interdigital gland there are large concretion-like masses almost filling the lumen. These are not seen in the tarsal gland apocrine tubules. These masses are: (1) without natural coloring, (2) colored black by Sudan black even after pyridine extraction for 24 hours, (3) stained pink by eosin, (4) colored red by PAS even after treatment with diastase, (5) stained blue by the Schmorl reaction, (6) stained pink by the Long Ziehl-Neelsen method, (7) frequently colored orange in the center by the Millon reaction, and (8) uncolored by chrome hematoxylin, ammoniacal silver, and PFAS. These reactions indicate that the masses contain some lipoprotein, at least centrally, and that, possibly, either or both phospholipid and glycolipid are present.

The staining reactions of the myoepithelium and the basement membrane are the same as those reported above for the tarsal gland.

A series of slides stained for nerve endings was particularly successful in showing the endings on apocrine glands and the arrector pili smooth muscle cells, both shown in Plate VI. In the apocrine tubules single nerve fibers are seen at the same level in the wall as the myoepithelial cells. These fibers course parallel to the myoepithelial cells and in close proximity to them, but no branchs of the fiber were seen to pass to them. However, short and very delicate branchs were sometimes seen passing to the neighborhood of the apocrine cells themselves. The terminal nerve networks on the smooth muscle cells of the arrector pili muscles are similar to those described for smooth muscle endings in other locations and species.

In the ventral interdigital skin (area D, Pl. I, lower right) of the hind foot, the sebaceous and sudoriferous glands are not enlarged and thus are much smaller than those in the glandular sac of the interdigital gland. The sudoriferous glands are apocrine. The apocrine secretory cells are mostly cuboidal in shape and have some ceroid lipofuscin granules, but these granules are smaller and not so abundant as those in the cells of the interdigital sac. Atrophied cells containing lipofuscin granules are not found. Tissue sections of this relatively unmodified area of the skin are unfortunately too few for an accurate appraisal of the cytochemistry of the apocrine cells and their secretion.

Forefoot interdigital gland.—The histology of the forefoot interdigital gland (Plate V) is like that of the gland of the hind foot with the following exceptions: (1) The sebaceous glands and arrector pili muscles are much smaller and are probably nearly the same size as those in unmodified areas of skin. (2) The apocrine glands are nearly but not quite as large as those of the hind foot gland and they are separated from each other by wide connective tissue partitions. As in the hind foot, there appear to be no sexual differences. With regard to the apocrine secretory cells, there is a close similarity between the glands of the fore- and hind feet. However, since slide material of the forefoot gland is not abundant enough for critical appraisal of some staining reactions, the cytological comparison of the two areas must be limited. The following facts are noted. In the forefoot interdigital gland apocrine cells as in the hind foot interdigital gland cells there is lipofuscin pigment which appears the same in all respects. It is found in most concentrated form in granules and masses in the secretion in the lumen of the tubules as well as in atrophied cells at the base of the epithelial layer. The lipofuscin masses in the secretion react with the various techniques in the same way as the atrophied cells and may represent, at least partly, such

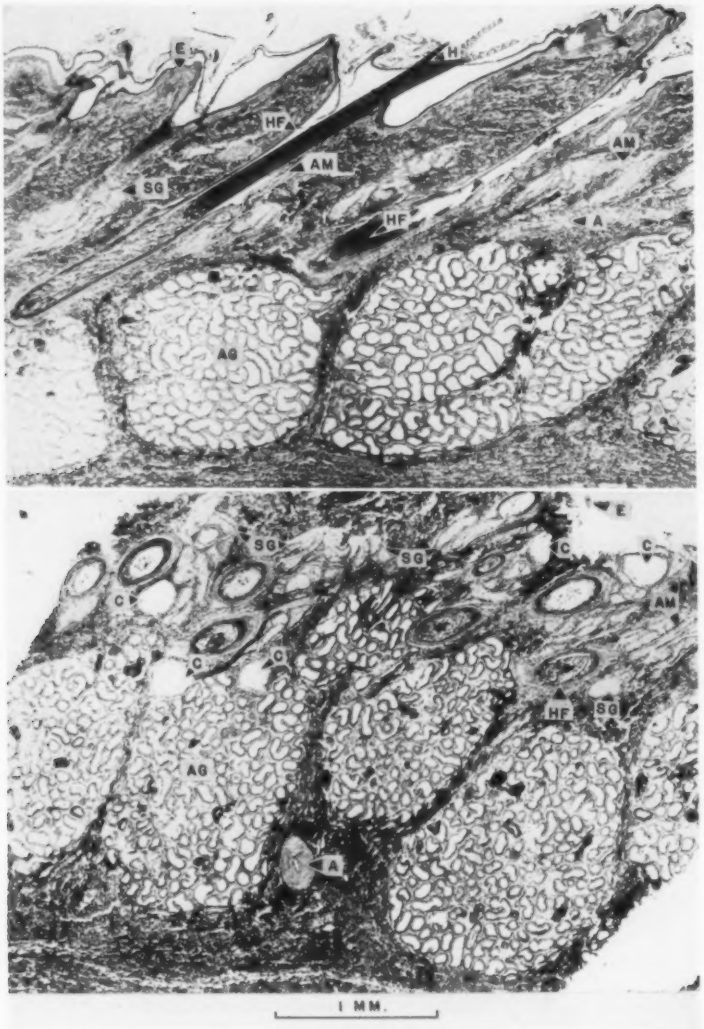


PLATE V

Vertical sections through the forefoot interdigital skin in its most glandular area. UPPER: Female. LOWER: Male.

Compare the arrector pili muscle and the glandular tissue with those of the tarsal and hind foot interdigital glands. Both stained with phosphotungstic acid hematoxylin and photographed to the same scale. A—arteries. AG—apocrine gland tubules. AM—arrector pili smooth muscle bundles. C—cysts of parasites. E—epidermis. H—hair shaft. HF—hair follicles. SG—sebaceous glands.

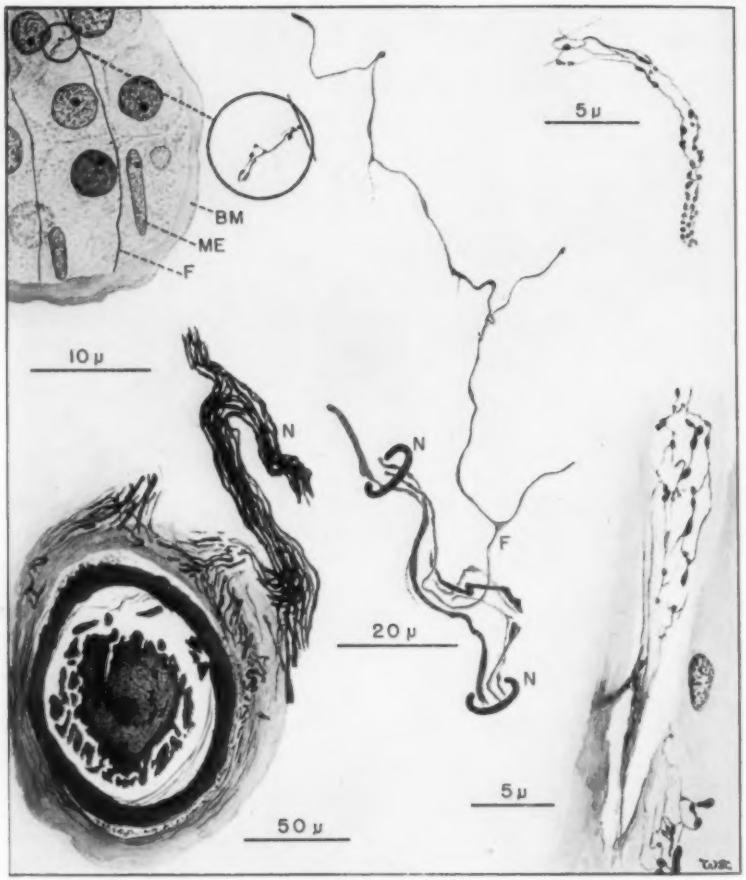


PLATE VI

Nerve fibers and endings in tissues associated with the glandular areas.

Upper Left: Tangential section of an apocrine tubule in the fundus of the hind foot interdigital gland of the female. BM—basement membrane. F—nerve fiber. ME—myoepithelial cell nucleus. Round nuclei belong to apocrine cells. Note the nerve fibers, which run at the same level as the myoepithelial cells and parallel to them. The insert shows a branch and ending on an adjacent apocrine cell.

Middle: Small nerve trunk (circled N) and branching fiber (F) with bulb-like swellings along the outer surface of a hair follicle at the posterior end of the preorbital pocket.

Upper Right: Terminal nerve net with swellings on an arrector pili smooth muscle cell in the hind foot interdigital gland of the male.

Lower Left: Cross-sectioned hair follicle at the posterior end of the preorbital pocket, showing rich nerve supply to the wall of the follicle. The hair shaft is central and was partly fragmented when sectioned. The epithelium of the follicle and the nerve fibers are black; the connective tissue sheath of the follicle is gray.

Lower Right: Terminal nerve nets on arrector pili smooth muscle cells in the hind foot interdigital gland of the male.

All material was stained by the modified Rogers, Pappenheimer and Goetsch method. In the drawings, the structures were first outlined with the aid of a camera lucida.

cells that have been sloughed into the lumen. PAS-positive material that corresponds in distribution and appearance to the glycogen in the apocrine cells of the hind foot, is found only rarely and even then in slight amounts.

Preorbital pocket.—The preorbital pocket is a depression in the skin anterior to the eye (Pl. I). In many artiodactyls the skin lining it is highly glandular. A review of what is known about this structure has been provided by Schaffer (1940). In the caribou the skin lining the pocket is thin, dense, unpigmented, and supports only a few small unpigmented hairs. The gross description of the pocket is much like that provided by Cowan (1936) for the preorbital gland in *Odocoileus*. The skin immediately rimming the pocket in the caribou is densely haired and is pigmented to a variable degree.

The histological characteristics of the preorbital pocket are as follows. The epidermis is thin. The stratum germinativum is usually from 2 to 4 cells in thickness and the strata lucidum and granulosum are not evident. Practically all of the corneum has been sloughed off. The dermis is thick and is composed of dense, irregular, primarily collagenous connective tissue. Passing vertically and obliquely through the dermis are fascicles of skeletal muscle fibers, which insert in the connective tissue close to and below the epidermis. Sebaceous glands, which are scattered and only slightly larger than the sebaceous glands of the rim of the pocket, secrete into saccular hair follicles. Scattered and widely separated in the dense connective tissue are small apocrine sudoriferous glands, which are only slightly larger than their counterparts in the external border of the pocket. The epithelial cells of the apocrine tubules vary from columnar to squamous in vertical section. Many of the tubules show a curious pattern of columnar epithelium on one side passing gradually into thin squamous on the opposite side. The significance of this is not known.

The appraisal of the composition of the apocrine cells must be limited, since in those tissue sections that are available, apocrine glands are few and small. The material is sufficient to demonstrate that: (1) The apocrine cells contain a PAS-positive material that has the same distribution and form as that that was identified as glycogen in the hind foot interdigital gland. This material is abundant in apocrine cells at the bottom of the pocket and is scant in apocrine cells at the anterior and posterior rims. (2) Lipofuscin granules are present. They have the same form, distribution and staining reaction with PAS, Sudan black, azure II, and the Long Ziehl-Neelsen method as those in the interdigital glands. (3) The cytoplasmic staining reactions with the Taenzer Unna technique are like those of materials in the hind foot interdigital gland.

The myoepithelium and basement membrane are similar in form and staining reactions to those described in the other areas.

The skin at the posterior rim of the preorbital pocket has a dense growth of hair. In the connective tissue of this area of skin there are many small nerve trunks. Slides treated for nerve endings show a rich nerve supply to the walls of the hair follicles (Pl. VI, lower left). Tangentially sectioned hair follicles frequently show fine nerve fibers zig-zagging up along the junction of connective tissue and external root sheath (Pl. VI, middle). Along and at the terminations of these fibers there are swellings. These nerve endings are found most frequently along the upper part of the follicles, and probably are stimulated when the hair is moved. Sinuses around the hair follicles, such as have been described in association with certain other hair follicle-nerve organs, are not found.

DISCUSSION

The apocrine sudoriferous glands are of unusual interest, since they show a great variety of cytoplasmic and secretory constituents, and also, marked sexual and topographic differences. Evaluation of these differences must be founded on a profound respect for possible variations due to age, season, sex, and individual peculiarity. Nevertheless, the difference in the size of the tarsal gland areas and the difference in the amounts of its glandular tissue in male and female strongly supports this as a sexual dimorphism. Also the differences in the cytochemistry of the tarsal gland apocrine cells and the interdigital gland cells seem

too marked to be taken lightly. However, the distinguishing features of the cytology of the hind foot interdigital gland apocrine cells in comparison with the apocrine cells of other areas, except possibly those of the tarsal gland, might be interpreted as the result of increased activity. Material identified as lipofuscin has been found in the cells of many specialized and diverse tissues in man, especially in older individuals, and is frequently thought of as a "wear and tear pigment." The abundance of this material in the apocrine cells of the interdigital glands suggests that the cellular activity here may differ primarily quantitatively rather than qualitatively, from that of other areas. The alternative hypothesis is difficult to support because the apocrine cells in other areas than the interdigital and tarsal glands are few per section and show less cytoplasm for study.

Comparisons of the specialized glandular areas of the caribou with those of other artiodactyls and mammals with respect to degree of development and cytochemistry would be premature at this time, since the available data for other species is fragmentary and often contradictory (Schaffer, 1940), due probably to the variables mentioned above.

In the literature on the specialized glandular areas in the skin of *Rangifer*, cited previously, and frequently in accounts of the behavior of *Rangifer*, there are speculations on the functions of these organs. It should be apparent, first of all, that the functional activity of a particular glandular area may not be the same in all species of artiodactyls, since there is such great interspecific and intergeneric variation in the amounts of glandular tissue in a particular organ (Cowan, 1936; Schaffer, 1940). Therefore, functions ascribed to a glandular area in one species may not hold true for another, even if these areas appear similar externally. The opinion that these specialized glandular areas are scent organs is probably the most popular and likely. If this belief is true, my data suggests that the tarsal gland may be a specialized scent organ of the female, the interdigital glands scent organs of use to both sexes, and the preorbital pocket of little use as a scent organ in either, in *Rangifer*. The function of the interdigital glands might be to leave scent identifying a particular group or individual, or to leave a warning scent when frightened (see Dugmore, 1913). To those who may have the opportunity of testing these ideas with living animals, the following experimental procedures are suggested: (1) coloring the tarsal patch the same shade as the surrounding fur, (2) increasing the area and brightness of the tarsal patch, (3) shaving the hair from the glandular areas and removing the secretion products of one or more of the areas with solvents and bactericidal solutions, (4) anesthetizing the area of one or more of the glandular areas, and (5) treating the areas or the animal with certain of the sex hormones by injection or by innunction. Animals whose glandular areas are treated in certain of these ways could be used to test: (1) ability to elicit mating activity, (2) ability to leave scent for other animals to follow, and (3) ability to leave scent warning other animals of danger.

SUMMARY

Skin samples of an adult male and an adult female caribou, collected in April in northern Alaska and fixed in formalin-alcohol, were studied histologically

and cytochemically. The skin samples represent four specialized areas: the tarsal gland, the fore- and hind foot interdigital glands, and the preorbital pocket. All of these areas contain both sebaceous and apocrine sudoriferous glands. The glandular development in these areas is the same in both sexes, except for the tarsal gland, which is considerably greater in surface area, thickness, and glandular development in the female. The glandular elements of the interdigital glands are highly developed, but those of the preorbital pocket are poorly developed. The cytochemistry of the apocrine cells of the tarsal gland is distinguished from that of the interdigital glands by the lack of lipofuscin and presence of aldehyde groups in the cytoplasm and by the presence of aldehydes, basophilia, and greater sudanophilia in secretion globules. Glycogen is identified in many of the apocrine cells of the hind foot interdigital glands on the basis of staining with periodic acid leuco-fuchsin and removal by diastase. Material of similar appearance and staining capacity, but not tested with diastase, is found in apocrine cells of other areas. Neither ferric nor ferrous iron could be demonstrated in the apocrine cells of these areas. Further details of histology and cytology are described and possible functions of the glandular areas are discussed.

LITERATURE CITED

Bensley, R. R. and S. H. Bensley. 1938. Handbook of histological and cytological technique. Univ. Chicago Press, Chicago. 162 p.

Caton, J. D. 1877. The antelope and deer of America. Ed. 2. Forest and Stream Publ. Co., New York. 426 p.

Cowan, I. M. 1936. Distribution and variation in deer (Genus *Odocoileus*) of the Pacific coastal region of North America. California Fish and Game, 22: 155–246.

Dugmore, A. A. R. 1913. The romance of the Newfoundland caribou an intimate account of the life of the reindeer of North America. J. B. Lippincott Co., Philadelphia. 191 p.

Jacobi, A. 1931. Das Rentier eine Zoologische Monographie der Gattung Rangifer. Akad. Verlagsgesellschaft m. b. H., Leipzig. 264 p.

Lillie, R. D. 1948. Histopathologic technic. Blakiston Co., Philadelphia. 300 p.

Oksala, V. I. 1927. Beobachtungen über den Sinus cutaneus ungularum beim Renntier. Anat. Anz. Cent. für die gesamte wiss. Anat., 64: 129–139.

Pearse, A. G. E. 1953. Histochemistry theoretical and applied. Little, Brown and Co., Boston. 530 p.

Pocock, R. I. 1910. On the specialized cutaneous glands of ruminants. Proc. Zool. Soc. London. 1910: 840–986.

Schaffer, J. 1940. Die Hautdrüsenorgane der Säugetiere mit besonderer Berücksichtigung ihres histologischen Aufbaues und Bermerkungen über die Proktodäaldrüsen. Urban & Schwarzenberg, Berlin & Wien. 464 p.

Tempel, M. 1896. Vergleichend anatomisch-physiologische Untersuchungen über die Drüsen der Zwischenklauenhaut der Paarzeher. Dissertation. Leipzig, p. 14 (cited by Jacobi, Schaffer, and Zietzschmann).

———. 1897. Die Drüsen in der Zwischenklauenhaut der Paarzeher. Arch. wiss.-prakt. Tierheilk., 23: 1–48.

Zietzschmann, E. H. 1903. Beiträge zur Morphologie und Histologie einiger Hautorgane der Cerviden. Zeitschrift für Wiss. Zool., 74: 1–63.

Department of Anatomy, University of Michigan, Ann Arbor, Michigan. Received September 4, 1954.

ANTLERLESS MULE DEER BUCKS

By W. Leslie Robinette and Jay S. Gashwiler

The few published accounts of antlerlessness in male cervids implies a comparative scarcity of this phenomenon. Accordingly the cases noted by the writers in mule deer males (*Odocoileus hemionus hemionus*) may deserve mention.

We are indebted to Dr. George Wislocki of the Harvard Medical School for a reference to antlerless adult male deer recorded in German literature. The following is a direct quotation from his letter of December 8, 1953.

"Rörig in 1907 (Gestaltende Correlationen zwischen abnormer Körperkonstitution der Cerviden und Geweihbildung derselben: Archiv f. Entwicklungsmechanik der Organismen, Bd. 23) on pages 8–10 and 13–14 lists a number of instances known to him or cited in the literature of deer without antlers but with normal genitalia. His compilation relates almost entirely to *Cervus elaphus* and *Capreolus*. He said that he found no evidence of anomalies of any sort in the reproductive organs, and there was good evidence that the animals were fertile and sexually active. In one case (and possibly two) the condition appeared to be hereditary because other animals of the same character were observed in the same locality. Adult males with total absence of antlers and abnormal genitalis are extremely rare, according to Rörig. On page 26 he cites an animal of this sort with small cryptorchid testes, and gives fragmentary data on four other cases."

Seton (LIVES OF GAME ANIMALS, Vol. 3, Part 1, p. 239, 1929) states, "I have never seen one (antlerless adult buck) but I have often heard of them and find several cases recorded." However, he actually cites but two references (J. B. McW., Forest and Stream 46: 454, June 6, 1896; and F. H. K., Forest and Stream 47: 5, July 4, 1896). The present writers have read only the latter reference in which the writer claimed to have killed a 160 pound buck without "horns" in Alcona County, Michigan in November, 1879. There was no statement regarding normalcy of the testes.

Darling (A HERD OF RED DEER, 1937) in his studies of red deer (*Cervus elaphus*) in Scotland states: ". . . about one stag in a hundred is without antlers and is known as a "hummel." The genetic absence of antlers in no way affects the sexual rhythm of the stag. Hummels have the reputation of being wary and resourceful, they are in better physical condition than other stags, and they are able fighters."

The first instances of antlerless or semi-antlerless mule deer bucks coming to the attention of the writers were two killed by hunters during late October of 1948 within the Oak Creek area of central Utah. One of these deer was an adult (estimated age—six years) that had no trace of pedicels (Plate I, at right in upper photograph). The buck weighed 156 pounds, hog-dressed, which exceeds by 25 pounds the heaviest and by 31 pounds the next heaviest doe of several hundreds from the area that we have weighed. Characters such as a swollen neck and a whiter face than is commonly found in does, together with portions of the penis sheath and scrotum remaining on the carcass provided added evi-

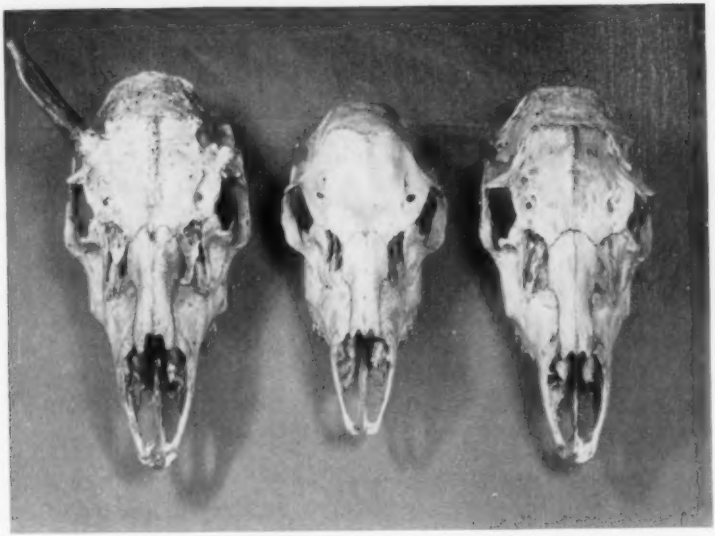


PLATE I

UPPER: On the left is the skull of a mature mule deer buck (estimated age five years) that supports a 3.5 inch spike antler on the right side and only a rudimentary pedicel on the left side. In the center is the skull of a mature doe (age nine years) for purpose of comparison. On the right is the skull of another mature buck (estimated age six years) with no trace of antlers or even pedicels.

LOWER: Head of a mature doe (left) and of mature buck whose skull appears at left in photograph above. Masculine features of the buck head are clearly evident despite near absence of antler growth.

dence that this animal was truly a male. In addition, the hunters stated that the testes were of normal appearance and size.

During the same hunting season and from the same area another buck was taken with a normal two-point antler on the right side but without even a rudimentary pedicel on the left side. Unfortunately, we did not question the hunter regarding the testes from this buck.

Verl Jacobsen of Oak City, Utah called our attention to a mature antlerless buck that he had killed during the early 1940's within the Oak Creek area. Photographs that he had taken of the deer revealed a marked similarity to the six-year antlerless buck mentioned above. This one also showed a neck swelling, and a frame much larger than that of a doe. Mr. Jacobsen states that the testes appeared normal.

During the 1952 hunting season two male fawns about four months of age that had no trace of pedicels were taken from the Oak Creek area. Verification of sex was obtained through portions of the penis sheath and scrotum remaining on the carcasses in addition to hunter statements. Both fawns were normal in size and condition.

Except for the fawns mentioned in this paper the writers have observed but a single male fawn that lacked pedicels at the time of the regular Utah hunting season, which is normally held the latter half of October when the average fawn is 4 to 4.5 months of age. This particular fawn was killed near Ephraim, Utah at about four months of age. It had been in an experimental enclosure, accidently separated from its mother, from the time it was a month of age. It was noticeably underdeveloped when shot, weighing less than 30 pounds, hog-dressed, as compared to a normal range of 40–55 pounds for four-months-old fawns in this area. Absence of pedicels was interpreted as a response to abnormal nutrition.

On December 3, 1952 while the senior writer was making field classifications of live deer for sex and age on the Oak Creek area, a yearling spike buck and an antlerless deer of similar size were noted having a friendly bout by placing their heads together at intervals and pushing one another about. This is a common trait among the immature bucks during the rutting season. Despite critical observations of the antlerless deer with a 30-power spotting scope from about 200 yards no signs of antlers or even pedicels were noted. It seems entirely probable that this could have been another antlerless buck.

Added to the foregoing records was another male fawn lacking pedicels and an adult buck with a single spike antler taken during the 1953 hunting season from the same area (Plate I—left skull in upper photograph and right head in lower photograph). The adult buck, estimated at five years of age, was killed by Marvin Lovell of Oak City, Utah. Weighing 202 pounds, hog-dressed, it was the third-heaviest deer taken from the area. Few deer from the Oak Creek area exceed 200 pounds. This particular animal had a large swollen neck and except for the antlers was typically male in appearance. According to Mr. Lovell the testes of this buck appeared normal. This animal was peculiar in possessing a single spike antler about 3.5 inches in length on the right side, and on the left side a small knobby malformed pedicel that failed to protrude through the skin.

Although we were unable to obtain the testes from any of these animals for histological study, we have the word of the hunters in all but one instance that the testes were normal in size and appearance and that in the case of the three large adult males there was evidence of neck swelling. Dr. Wislocki (letter of December 8, 1953) states "... it would seem to me likely that neck swelling is caused by testosterone and I presume that animals showing such swelling would be fertile." Verification of the first part of this statement is furnished in studies by Dr. Wislocki and co-workers (Endocrinology, 40: 202–224, 1947). These writers report the case of a two-year-old buck, castrated in June, that in the following November failed to exhibit the usual rutting behavior and swollen neck of normal bucks.

Because of the tendency of sheepherders and cattle riders in many parts of the West to castrate young fawns that they find, it would be entirely possible for some of these castrates to be taken later by hunters. However, we doubt that any of the bucks under discussion were castrated because of hunter statements attesting to normalcy of the testes and because of the swollen necks exhibited by the mature bucks.

All of the bucks lacking pedicels or one or both antlers, which the writers have observed throughout several years of mule deer studies in Utah with the single exception of the underdeveloped fawn, have been taken from the Oak Creek area, an area only slightly larger than a single township (36 sections). This condition supports the theory that the anomaly could have been genetically caused.

This note is a contribution from the Utah big game, livestock and range relationships study.

U. S. Fish and Wildlife Service, Salt Lake City, Utah and Corvallis, Oregon.
Received August 30, 1954.

SOME FACTORS AFFECTING FLUCTUATIONS OF *MICROTUS* AND *PEROMYSCUS*

By E. W. Jameson, Jr.

For many years there has been a tendency for workers to search for broad concepts or master factors to explain cyclic changes in numbers of animals. Many writers have proposed that cosmic forces act to effect rather uniform population cycles in many kinds of animals, and that a single grand theory can explain the variations in numbers in different kinds of animals. We have gradually come to believe that such an approach is unnecessary, and may even be undesirable if it deters students from considering the plausibility of other explanations. It may be appropriate to determine, if possible, the reasons why a given population becomes alternately abundant and scarce. If we do this for various kinds of animals, we may then more completely evaluate proposed theories that attempt to cover fluctuations as a whole.

In order to show how different factors may act in population changes, it is interesting to compare such changes as they occur in meadow mice (*Microtus* spp.) and deer mice (*Peromyscus* spp.). In studying changes in the population levels of small rodents, the student is beset with inconstancies and contradictions and it is sometimes impossible to prepare a clear and simple explanation of the observed data. There appears to be regularity in the population changes for some microtine rodents, but there is no apparent pattern for the extreme differences sometimes observed in deer mice (*Peromyscus* spp.).

FLUCTUATIONS OF DEER MICE

Because deer mice are not generally considered to be of economic importance in agricultural areas and because an abundance of these rodents frequently goes unnoticed, there are few persons concerned with following their fluctuations. Whether cyclic or not, there may be great changes in the numbers of deer mice in different years; this has been observed and published many times by different workers. One may also, simultaneously, find striking differences in populations of deer mice in one small region, the abundance of one species varying greatly in neighboring and apparently optimum habitats. Thus, in habitats only a mile apart, one species of *Peromyscus* may have different population levels, and such populations may conceivably fluctuate independently of each other. Also, two kinds of deer mice may in one area become abundant and scarce at different times, one species building up during the decline of the other. This was observed in the Sierra Nevada of northern California for *Peromyscus maniculatus* and *P. boylii* (Jameson, Jour. Mamm., 34: 44–58, 1953). One naturally wonders if the previous abundance of *boylii* had not somehow held down the increase of *maniculatus*; the possibility of such relationships deserve careful attention.

The above fluctuations were studied by trapping rather continuously over a three year period. Ecologically, there were three populations of *Peromyscus:* (1) *maniculatus* living in the coniferous forest, (2) *maniculatus* in the brushfield, and (3) *boylii* in the brushfield (*boylii* did not occur in the coniferous forest).

Life histories of these three groups were similar but not identical; ecologic as well as specific differences were observed in their food, and the two species differed in their reproductive cycles. In addition there were variations in the food and reproduction over the three year period.

Relationships between food and reproduction, and subsequently upon abundance became apparent, and have been discussed previously. Although *Peromyscus* may feed upon a wide variety of foods, the use of important items varies directly with availability (Jameson, Jour. Mamm., 33: 50–60, 1952); and these variations are accompanied by changes in reproductive rates and population densities (Jameson, 1953). The magnitude and prevalence of a crop failure of pine seeds, manzanita berries, acorns or some other type of mast would affect the limits of a deer mouse fluctuation. A crop failure might be local or widespread, but would possibly involve several kinds of important foods before affecting deer mice in different habitats. If the crop failure affected only one kind of food, its effect would be less and would probably affect the mice living in fewer habitats.

Variations in the kind and abundance of food affected the reproduction of deer mice in late summer and autumn. Reproduction in the spring seemed essentially similar over the three year period; but in the autumn, breeding activity was favored by an abundant supply of food. In years when pine seeds, Douglas fir seeds, manzanita berries, and acorns were produced, deer mice continued breeding through the autumn until December; and a large population built up. In the absence of such foods, these mice ceased breeding in June; under such circumstances, a potential addition to the population never materialized. A year of scarcity of mast was followed by a scarcity of deer mice. No excessive mortality was observed at this time; the decline is believed to have resulted from a lull in reproduction rather than an increase in mortality (Jameson, 1953: 56).

One could describe many more instances in which local populations of deer mice exhibit such differences in density, composition and food. Some species of *Peromyscus* (especially *maniculatus*) seem to thrive in many diverse types of environment; and it is only natural that these populations are slightly different in separate (but sometimes adjacent) habitats. In a larger region, of several hundred square miles for example, there seems to be a mosaic of populations of *maniculatus*, each one behaving more or less as a unit and often differing from the neighboring population.

A COMPARISON OF FLUCTUATIONS IN MICROTUS AND PEROMYSCUS

There are apparent several basic differences in the fluctuations of some microtine rodents, on the one hand, and some kinds of deer mice (*Peromyscus* spp.) on the other. These differences may account, in part at least, for the lack of clarity and synchronization in fluctuations of deer mice in contrast to the rather regular and sometimes widespread cycles apparently typical of many voles and lemmings.

Adaptability.—Deer mice (*P. maniculatus* and others) may thrive in a variety of habitats. They are almost always found in old, uncut forested areas, and they are among the first mammalian invaders in disturbed habitats. Although various

kinds of *Peromyscus* do have habitat preferences, such preferences are generally elastic. On the other hand many species of voles (especially *Microtus* spp.) occupy a characteristic environment; commonly each species remains in its chosen habitat and seems not to be very adaptable in this respect (e.g., Bernard, Bul. Inst. Agronomique et Sta. Recherches Gembloux, 21: 3–13, 1953).

Quality of food.—Although both deer mice and field mice subsist on a large variety of foods, there is a basic difference between the diets of the two groups of mammals. Deer mice feed largely upon the fruiting parts of various plants, mostly the mast produced by trees and fruiting shrubs. *Microtus* most commonly feeds upon vegetative parts of plants (including leaves, stems and roots); usually these are grasses and forbs, but occasionally they consume vegetative parts of woody plants (including the cambium).

Variations in food.—It is important to consider the fluctuations of the food materials of these two groups of mice. The production of berries, acorns, pine nuts and other fruits of woody plants is highly variable from year to year; thus, the stable foods for deer mice may be abundant one year and absent the next, or mast production may vary greatly in adjacent habitats at the same time. The production of forbs and grasses, on the other hand, though it may be variable, is far more regular than fruit production. If a forb or grass has life, it will show some vegetative growth and so provide food for *Microtus*.

Effect upon the environment.—As a consequence of the above-noted differences in type of food, *Peromyscus* spp. and *Microtus* spp. exert different sorts of biological pressure upon their environment. A very dense population of *Peromyscus* does not appreciably alter the plant cover; the leaves they eat are proportionately small in amount, and the consumption of large amounts of seeds and berries seems to have no obvious effect on the habitat. The effect of a high population of many kinds of *Microtus* on plant cover can be seen even by the unintiated; the herbaceous ground cover may be scanty, ragged, and brown due to the consumption of stems, leaves, and roots by *Microtus*. These mice may literally destroy their own habitat.

Reasons for the lack of uniformity in fluctuations of *Peromyscus* are apparent, but the widespread synchronization of some microtine cycles remains a puzzle. The stress concept offers a possible explanation for the decline of microtine populations. The effect of stress (produced by fighting) in *Microtus* is the subject of a recent paper by Clarke (Jour. Endocrin., 9: 114–126, 1953); enlargement of the adrenals occurred apparently as a consequence of fighting among captive voles. The decline frequently observed in *Microtus* is rather sudden and could possibly result from the effect of stress on more than one generation (Chitty, Phil. Trans. Royal Soc. London, ser. B, 236: 505–552, 1952). It would be of great interest to compare the effect of stress on *Microtus* with its effect on *Peromyscus*; the two genera may quite possibly differ in this respect. It will be of value, also, to compare *Peromyscus* with *Apodemus* regarding all the topics discussed in this paper.

The distinctions observed in the habits and environmental responses of *Peromyscus*, on the one hand, and of *Microtus*, on the other, indicate some rather

important differences in the nature of their population fluctuations. These differences are such that it is erroneous to assume that population changes in the two groups represent the same phenomenon. By comparing the nature and causes of fluctuations of different kinds of vertebrates we may then be able to understand the degree of association of population cycles of different animals.

Department of Zoology, University of California, Davis. Received May 24, 1954.

OBSERVATIONS ON THE NATURE OF THE DECLINE IN NUMBERS OF TWO *MICROTUS* POPULATIONS

By Gillian K. Godfrey

Microtus populations are known to be subject to marked fluctuations in numbers, with periods of peak abundance alternating with periods of scarcity, and recurring at approximately four-year intervals. In 1952 Chitty advanced an hypothesis to account for the 'crash' of the voles at the end of each period of abundance, explaining the severe mortality at this stage of the cycle as resulting from conditions to which the parents had been exposed during the previous (i.e. peak) breeding season, and not from abnormal environmental conditions affecting the progeny at that time or during the decrease. This view is developed more fully by Chitty (1954). The hypothesis is based on evidence obtained during a study of vole populations in Wales where severe mortality occurred among the first-born young during the peak breeding season. Young born later in the season had a higher survival rate at first, but decreased rapidly during the winter, and on some areas the survivors did not breed again in the following year. Even where breeding did occur, the population still experienced a crash. He postulates that intraspecific strife occurs during the peak breeding season, causing the death of the first-born young and a permanent derangement of the physiological condition of the adult females. Defects in the females are believed to be transmitted in a more severe form to the next generation.

Some information that appears relevant to this hypothesis was obtained during a study of voles (*Microtus agrestis*) on two isolated areas of natural grassland in the Oxford University Estate at Wytham, Berkshire, between 1949 and 1952. Intensive live-trapping showed that the voles on the smaller area (the Dell = 2 acres) reached a peak in 1950 and crashed in 1951, while those on the larger area (Rough Common = 4½ acres) reached a peak in 1951 and crashed in 1952.

Longworth live-traps (Chitty & Kempson, 1949) were placed singly near the centre and corners of the 15 yd. squares that formed a permanent grid over the study areas. The actual trap-sites were varied in consecutive trapping periods. The voles' ranges were large in relation to the distance between traps (Godfrey, 1954), and since there was always a high proportion of unoccupied traps (at least 75%), the numbers used may be assumed to have been more than adequate. The traps were set without prebaiting in 1950, and were left in position for 3–5 days at a time. They were set each morning, emptied at noon and in the

evening, and closed overnight, so that nursing females were not away from their young for longer than 5–6 hours. Trapping was carried out at approximately 10-day intervals. In 1951 two nights were spent prebaiting before the traps were set. Catches were taken at noon, in the evening, and on the following morning, and voles caught on the first two occasions were held in tins. Trapping was carried out twice a month.

Population estimates cannot be given since the basic assumptions involved in the marking-recapture methods of estimation were unfulfilled. In addition to the errors found by Leslie *et al.* (1953), i.e. that marked and unmarked animals were not equally at risk, further errors appear to have been introduced by the fact that even the marked animals were probably not randomly sampled. This contrasts with the findings of Leslie *et al.*, and may perhaps be the result of trapping at too frequent intervals; in their study the population was retrapped at intervals of 28 days or more.

The numbers of voles trapped in May and August during 1950–52 serve to show the trend of the population changes on the two areas (Table 1). The fact that fewer voles were caught on the Dell in August, 1951, than in May, in spite of 3½ months continuous breeding, suggests that the young suffered considerable mortality. (Adults are usually scarce by August and form only a small proportion of the total population.) In the previous peak year, there was an appreciable increase in numbers over the same period. The scarcity of grass cuttings and droppings on the Dell in May, 1952, confirmed that the population was in fact practically extinct, and not merely avoiding the traps. On Rough Common, events were similar but occurred one year later (Table 1).

Voles in Wytham undoubtedly reached peak populations at lower densities than those reported hitherto. Although estimates of population size could not be obtained, trapping evidence suggests that there were considerably fewer than

TABLE 1.—*Numbers of voles* (marked and unmarked) trapped in Wytham in single periods in May and August, 1950–52*

Month	Dell			Rough Common		
	Ad.	Juv.	Total	Ad.	Juv.	Total
1950						
May	8	4	*12*	7	0	*7*
August	6	23	*29*	0	21	*21*
1951						
May	36	0	*36*	14	2	*16*
August	0	9	*9*	13	87	*100*
1952						
May	?	?	*3*	32	3	*35*
August	—	—	—	6	5	*11*

* Young unmarked animals were distinguished from adults by their weight and the condition of their fur. Errors of classification are believed to be too small to affect the conclusions drawn in the text.

Chitty's estimate of 120 voles to the acre in Wales at the start of the peak breeding season (i.e. fewer than 240 on the Dell and 500 on Rough Common). It is extremely unlikely too, that the populations in Wytham in the autumn of the peak year reached, or even approached the figure of 300 per acre recorded by Chitty at Lake Vyrnwy in September, 1937. The lower population densities in Wytham were probably associated with a less favourable habitat: the dominant grass on the study areas is the relatively coarse *Brachypodium pinnatum*.

It is probable that there was a high rate of juvenile mortality on the Dell during the first part of the peak breeding season (1950) similar to that observed by Chitty (1952), for few young were caught until July (Table 2) although most of the females trapped in April and May were pregnant or lactating. The data do not prove that the young were dying: they may have been avoiding the traps or been kept away by the adults, and unfortunately, nothing is known about the previous year on the Dell. However, by comparison with Rough Common in 1950 and again in 1951, it looks as though more young might have been expected—at least by June—than were actually caught. (The reason for the small catch on Rough Common in July, 1950, is not known).

In the peak year (1951) on Rough Common the first litters were not born until the first week of May, three weeks later than in 1950, and this accounts for the small catch of young in May, 1951. It is thus difficult to draw any other inferences from the total catches in the two years, but a comparison may be made of the survival rates of the sexes. In 1951 (Table 3) the young males apparently

TABLE 2.—*Total numbers of unmarked juveniles* captured during all trapping periods in the breeding season*

Area	Year	April	May	June	July	Aug.	Sept.
Dell	1950	3	3	6	13	20	19
R.C.	1950	0	20	31	8	18	11
R.C.	1951	0	2	28	53	73	58

* See footnote for Table 1.

TABLE 3.—*Relative survival rates of young males and females on Rough Common*

	1950		1951	
	No. Released	No. recaptured	No. released	No. recaptured
June–July				
♂♂	15	7	16	1
♀♀	15	6	10	5
July–Aug.				
♂♂	7	3	28	5
♀♀	10	6	31	11
Aug.–Sept.				
♂♂	17	8	29	8
♀♀	10	4	58	25

survived less well than females, for only one out of the 16 released in June was recaptured in July compared with five out of the ten females. Similarly in August, five males were retaken from 28 released in July compared with 11 out of 31 females. No such differences in survival rate were apparent in 1950.

Several of the adult males trapped on both the Dell and Rough Common bore obvious signs of fighting. One male had already lost its tail when it was first captured, and another lost its tail in the interval between two trappings. Many of these animals had scars at the base of the tail; one had scars on the rump as well, and another scars on the scrotal area. In nearly all these cases some of the toes were damaged or missing.

Breeding occurred on both areas in the year of the crash, but few young survived. Thus 16 of the 18 adult females examined on the Dell in early May, 1951, were pregnant, and when they were palpated to determine the number of embryos, (Godfrey, 1953*a*) an average of 4.2 embryos per female was obtained. There were thus no less than 67 potential young in this sample alone. Yet only six were caught. This suggests that the young suffered severe mortality since many of the old females themselves were still present in June. The mortality is unlikely to have occurred in the late foetal and early nestling stages since most of the females trapped at the end of May were still lactating, and indeed, direct observations on two out of three litters showed that death occurred just before or just after weaning, which occurs about 14 days after birth. The young in two of the litters did not increase in weight after the first week, and their eyes, which normally open on the 9th day, remained closed. In one of these litters two of the four young died before the 11th day, and the two others and all four from the second litter were extremely feeble when last seen, just before they left the nest. The immediate causes of death are unknown. The young were evidently receiving some food since both the mothers were lactating. The mothers were wearing leg-rings containing radioactive cobalt (Godfrey, 1954), but as they had worn the rings for only three and five days respectively when their litters were born, the gamma radiation is unlikely to have affected the young. Moreover, the mother of the third litter, which left the nest at normal weight, had been carrying a radioactive ring for 46 days. Two of its young disappeared (ring of one recovered) within a week of leaving the next, but the third was still alive two months later.

Discussion.—In his hypothesis, Chitty postulates that the high death rate in the population after the peak is a consequence of intraspecific strife among the adults in the previous year, i.e. that their descendants are predisposed to die more readily from the normal causes of mortality. The observations in Wytham are not inconsistent with this view, but we should consider what other explanations could account for the failure of the young to survive.

There was no evidence that food was short. The voles were known to be eating every species of grass on the areas (Godfrey, 1953*b*), and there was little sign of general damage to vegetation as frequently observed in periods of vole abundance (Elton *et al.*, 1933; Chitty, 1952). There was no evidence from body weight or general condition that voles were starving during the peak year or following

winter, and the crash itself proceeded throughout the growing season of the grasses. There was little support for the suggestion advanced by Lack (1954) that food shortage can account for mortality of the type described here.

There is no reason to suppose that disease alone was sufficient to have killed the young, for out of approximately 900 voles marked between 1949 and 1952, only one showed outward signs of disease. Unfavourable weather, such as extreme heat or cold, might have caused some deaths among newly-weaned young, but by itself it is unlikely to have eliminated the young on one area without affecting those on the other area half a mile away. Moreover, in the year when there was severe juvenile mortality on the Dell the young on Rough Common apparently survived fairly well. Unfortunately, almost nothing is known about the part played by predators in the regulation of vole populations. Several weasels (*Mustela nivalis*) were caught on the study areas in vole traps; on one occasion the ringed leg of a vole was found in a trap with a weasel. Shrews, particularly *Neomys fodiens*, are also possible predators. Other predators include the fox (*Vulpes vulpes*), stoat (*Mustela erminea*), barn owl (*Tyto alba*), tawny owl (*Strix aluco*) and kestrel (*Falco tinnunculus*). We do not know enough about the effects of predation to say that a particularly heavy invasion of predators could not have killed nearly all the young, especially the males, on the Dell in 1951 and on Rough Common in 1952 without also killing the adults at a similar rate.

So far as these observations go, they provide no evidence that the higher morality rates in the crash years were the result of abnormal environmental conditions; on the other hand, they do not provide sufficient grounds for rejecting Chitty's hypothesis.

Summary.—In a live-trapping study, two isolated populations of field voles (*Microtus agrestis*), half a mile apart, were found to decrease in different years. The severe mortality at the time did not appear to be the result of unusual environmental conditions. The field observations were not inconsistent with the hypothesis advanced by Chitty (1952) that, in the year of the crash, the overwintering animals are abnormal from birth as a consequence of strife among their parents in the previous breeding season.

Acknowledgements.—This work was carried out at the Bureau of Animal Population, Department of Zoological Field Studies, Oxford University. Acknowledgement is made to the Director, Mr. C. Elton, F.R.S., for the provision of the Bureau's facilities, and to the University authorities for permission to work in Wytham estate. I am indebted to Dr. Dennis Chitty for advice and encouragement throughout the study.

LITERATURE CITED

Chitty, D. 1952. Mortality among voles (*Microtus agrestis*) at Lake Vyrnwy, Montgomeryshire in 1936–9. Philos. Trans. B, 236: 505–552.

———. 1954. Tuberculosis among wild voles: with a discussion of other pathological conditions among certain mammals and birds. Ecology, 35: 227–237.

Chitty, D. and D. A. Kempson. 1949. Prebaiting small mammals and a new design of live trap. Ecology, 30: 536–542.

Clarke, J. R. 1953. The effect of fighting on the adrenals, thymus and spleen of the vole (*Microtus agrestis*). Jour. Endocrin., 9: 114–126.

ELTON, C., D. H. S. DAVIS AND G. M. FINDLAY. 1933. An epidemic among voles (*Microtus agrestis*) on the Scottish border in the spring of 1934. Jour. Anim. Ecol., 4: 277–288.

GODFREY, G. K. 1953*a*. A technique for finding *Microtus* nests. Jour. Mamm., 34: 503–505.

———. 1953*b*. The food of *Microtus agrestis hirtus* (Bellamy, 1839) in Wytham, Berkshire. Säugetierkundliche Mitteilungen, 1: 148–151.

———. 1954. Tracing field voles (*Microtus agrestis*) with a Geiger-Müller counter. Ecology, 35: 5–10.

LACK, D. 1954. Cyclic mortality. Jour. Wildlife Mgt., 18: 25–37.

LESLIE, P. H., D. CHITTY, AND H. CHITTY. 1953. The estimation of population parameters from data obtained by means of the capture-recapture method III. An example of the practical applications of the method. Biometrika, 40: 137–169.

RANSON, R. M. 1934. The field vole (*Microtus*) as a laboratory animal. Jour. Anim. Ecol., 3: 70–76.

Bureau of Animal Population, Department of Zoological Field Studies, Oxford University, Oxford, England. Received August 30, 1954.

CONTRIBUTION TO THE LIFE HISTORY OF *SOREX VAGRANS* IN MONTANA

BY RONALD R. CLOTHIER

During the period extending from October, 1948, through the first part of September, 1950, and the summers of 1951 and 1952, the author collected shrews in western Montana for a study of the taxonomic relationships of the *Sorex vagrans-obscurus* group (Clothier, 1951). The present study is based upon 306 specimens of *Sorex vagrans monticola* from this series for which sufficient amounts of life history data were available. Of these specimens, 188 were collected by the author, and 118 were obtained from other collectors. Seventy-seven were collected near Missoula, Missoula County, fifty-four were collected near Yellow Bay, Flathead Lake, Lake Co., and 137 were collected in Glacier National Park. An effort was made to collect shrews throughout the year, but most of the specimens were obtained during the spring, summer and early fall months. The numbers collected each month were: January—8, February—16, March—26, April—22, May—12, June—40, July—80, August—46, September—42, October—23, November—5, and December—6. Specimens were prepared as study skins and skulls whenever possible, and in all cases the bodies were fixed entire in an alcohol-formalin-acetic acid mixture (Guyer, 1936) for a few days, then preserved in 70 per cent ethyl alcohol.

Acknowledgments.—The author is indebted to Clinton H. Conaway, Charles D. Haynes, and many others who have contributed specimens, and especially to Dr. Philip L. Wright, of the Zoology Department of Montana State University, who not only provided many specimens, but also generously supplied assistance and guidance through most of the period of this study.

Age.—The age of all specimens was determined by a method similar to that used by Conaway (1952). Measurements of the heights of several teeth of each

specimen were taken with an ocular micrometer used in a ten power binocular dissecting microscope, and totaled to give a tooth wear index. The measurements taken were as follows: the distance from the superior border of the cingulum on the buccal side to the apex of the left second upper unicuspid, the same measurement on the right second upper unicuspid, the distance from the cingulum to the tip of the highest cusp of the left first upper tricuspid, the same measurement on the right first upper tricuspid, the distance from the cingulum to the tip of the protoconid of the left lower first molar, and the same measurement on the right lower first molar.

There is a gradual decrease in the means of the tooth wear indices of specimens taken from month to month, and while there is a considerable overlap in the range from one month to the next, there is a marked gap between the ranges in immature and adult shrews. There was no evidence that any individuals had lived through more than two summers. Pearson (1945) and Blair (1948) in working with *Blarina brevicauda*, and Hamilton (1940) in working with *Sorex fumeus* also concluded that few, if any, shrews live through more than two summers. Since the earliest pregnant females taken in this study were collected in April and the latest in August, this would mean that the oldest specimens taken (the latest that a shrew born the previous year was captured was on November 1) are probably not over eighteen months old and are possibly only fifteen to sixteen months old. The youngest shrews trapped in June would probably be from one to two months old.

Variation of size with age.—The following measurements were taken with a vernier caliper on all skulls, except where broken parts prevented accurate measurements: condylobasal length, greatest cranial breadth, least interorbital breadth, greatest maxillary breadth, and greatest cranial height. The palatal length and the maxillary tooth row length were measured by means of an ocular micrometer used in a ten power binocular dissecting microscope. External body measurements were taken whenever possible. A comparison of the standard deviations of the means of all these measurements of different age groups indicates that with the possible exception of the cranial height, there is no significant variation of any of these measurements with age. The cranial height data were subjected to an analysis of the variance according to the method given by Snedecor (1946: 233), and the results indicate that the amount of variation obtained in this sample is not large enough to be considered significant at the five per cent level. Apparently by the time the young shrews are out of the nest and taken by traps, they have attained their maximum skull size and body measurements. There were no significant differences between cranial measurements and body measurements of males and females.

Elevation.—Although most of the specimens used in this study were obtained from elevations of 3,000 to 4,000 feet in the Canadian Life Zone, an effort was made to determine the upper limit of their distribution in Glacier National Park. Traps were set out in the Logan Pass Area in locations where shrews might be expected to be found. This portion of the study included approximately 400 trap nights at elevations ranging from 6,000 to 6,700 feet. In this area, the elevations

of 6,000 and 6,700 feet approximately mark the lower and upper limits of the Hudsonian Life Zone, as defined by Bailey (1918) and illustrated in his detailed topographical map of the life zones of Glacier National Park. No shrews were captured in this area. Shrews were collected in the upper parts of the Canadian Life Zone in areas near Logan Pass. Jackson (1928) reports that two specimens of *Sorex obscurus* (= *S. vagrans*) from an elevation of 5,300 feet about three miles south of Logan Pass, and I have two specimens collected by Bailey (1918) at elevations between 5,000 and 6,000 feet in the same general area. It is probable that in Glacier National Park the upper limit of the Canadian Life Zone marks the upper limit of the common occurrence of these shrews.

Habitat.—According to Jackson (1928), these shrews are found in meadows, marshes, along creek banks, and in moist woods. Bailey (1918) reports that in Glacier National Park he found these shrews in woods under logs or rocks, along creek banks, and in meadow grass. Dalquest (1948) states that *Sorex vagrans* is rarely taken away from water in Washington.

Early in this study it was noted that traps set under overhanging roots along small streams, in damp meadows, in patches of *Equisetum*, and in other damp situations were by far the most productive of shrews. Since the primary objective during this trapping was to obtain as many specimens as possible, most of the subsequent trapping was done in these habitats, and no attempt was made to accurately delimit the habitats of these shrews. A record was kept of the habitats in which shrews were taken, their distance from water, and the type of water. Shrews were taken in open grassy meadows at distances of from zero to 450 feet from water (small and large creeks, irrigation ditch, small standing pools, lakes), under overhanging banks, under roots or rocks at distances up to sixty feet from water, in patches of *Equisetum*, and in fairly dry woods around deadfalls up to 600 feet from water. However, by far the most shrews were captured in damp areas near water. All were taken in what is described by Bailey (1918) as the Canadian Life Zone.

Activity.—Although most of the traps were set out during the night, specimens were also taken in traps set out only during the middle of the day. The evidence available would indicate that these shrews are active both day and night. Specimens were taken throughout the year, and tracks and trails seen in the snow during the winter indicate that they are active even when temperatures are very low and large amounts of snow are on the ground. Specimens were taken in traps set in sheltered spots during severe winter storms. Rand (1948) states that they are active in Alberta throughout the winter at temperatures as low as −40°F.

Associates.—Throughout the period of trapping, *Sorex cinereus*, *Peromyscus maniculatus*, *Microtus pennsylvanicus*, and *Microtus longicaudus* were commonly taken in traps set in the same habitat in which *Sorex vagrans* specimens were captured. Occasionally in the summer, *Zapus princeps* was also taken. *Sorex vagrans* and *S. cinereus* were often taken in the same habitats, but there were always three to four times as many *S. vagrans* as *S. cinereus* captured. It is quite possible that further intensive study of the habits of these two species of shrews will reveal differences in their ecological niches, but none were noticed in this study.

TABLE 1.—*Contents of 137 shrew stomachs, Sorex vagrans*

Items in stomachs	Number of stomachs in which each item occurred
Insect (type unidentified)	88
Annelida (Oligochaeta)	63
Shrew hair	23
Insect larvae	22
Vegetable matter	20
Spiders	3
Insect eggs	2
Bone and muscle	1
Louse	1
Flea	1
Insect pupa	1
Small snail	1
Mite	1

Food habits.—The stomachs of 137 specimens were examined under a binocular dissecting microscope, and the general contents were identified (Table 1). The material in the stomachs consists mostly of finely divided fragments and is often difficult to identify accurately. The material listed as "insect" probably includes both adults and immatures. "Vegetable matter" includes any plant material found. This consisted of mostly small rootlets and young sprouts. It is apparent that these shrews feed mostly on insects, earthworms and other small invertebrates, and also some plant material. Stomachs examined from specimens taken in different months throughout the year do not reveal any significant differences in the major types of foods eaten. The presence of shrew hair in several stomachs indicates the possibility of cannabalism among these shrews, although it is possible that this hair came from *Sorex cinereus* individuals, since the hair of the two species could not be distinguished. It is also possible that the hair may have been picked up by the shrew licking itself. The absence of hair of any other mammals indicates that these shrews probably rarely, if ever, prey on the other small mammals common in the same areas. A deermouse was placed in a cage with one of these shrews, and they remained together for two days. During this time neither seemed to take much notice of the other.

Reproduction.—The sex of mature individuals was determined by macroscopic examination, and in immatures, by examination of the reproductive organs under a ten power binocular dissecting microscope. After preservation, the maximum and the minimum diameters of the testes were measured with a vernier caliper calibrated to .1 millimeter. One testis and its accompanying epididymis from each male born the previous year, collected after January 1, was sectioned, stained, and examined to determine whether or not spermatozoa were present. The ovaries and uteri of all females taken in March and April were serially sectioned, stained, and examined for the presence of corpora lutea or embryos.

Of the 306 specimens in this study, 130 were males, 138 were females, and 38 were not sexed by the collectors. These trapping results indicate that the numbers of the two sexes are probably about equal in the population.

The earliest evidence of pregnancy found was in a female collected on April

1, 1949, in which early cleavage stages were found in the oviducts. This female was also the earliest in which corpora lutea were found in the ovaries. The latest evidence of pregnancy was in a specimen collected on August 8, 1950, which contained four embryos. In thirty-two gravid females that contained embryos large enough to be counted accurately, the number of embryos varied from two to nine, with a mean of 6.4. Dalquest (1948) reports that he found from three to eight embryos in *Sorex vagrans* from Washington with the average number per female being six (number of females not given). With two exceptions, all pregnant or parous females examined were individuals born the previous year, as judged by the amount of tooth wear. One exception was a young female collected on July 30, 1949 by Dr. Philip L. Wright. This shrew was a parous individual, and later microscopic examination of sections of the mammary glands showed them to be in an active condition. The other exception was a young female collected on July 21, 1950, which contained two embryos. The teeth of both of these shrews showed no sign of wear, so there is little doubt that they were probably not over three months of age. Of the large number of other young females examined by me, none showed any sign of reproductive activity, and the reproductive tracts were so minute that a microscope was often used to sex them.

Post-partum mating has been described for several species of shrews. Hamilton (1949) states that both *Blarina* and *Sorex fumeus* mate post-partum. Only one specimen in my collection showed definite signs of having mated more than once. This specimen was collected by Dr. Philip L. Wright on July 3, 1949. She contained three small embryos and the nipples showed signs of being suckled.

All young males, up through and including those captured on January 24, have minute testes (less than 1.0 x 1.5 millimeters) which show no signs of development. Males taken after February 1 have enlarged testes (1.7 x 2.1 mm. or more), and a male captured on February 26 had spermatozoa in the testis and the proximal portion of the epididymis. With the exception of one specimen taken on March 7, all adult males taken after March 2 had spermatozoa in both the testis and epididymis.

The mean weight of both males and females during the months in which reproductive activity was absent was 4.74 grams with no significant difference between males and females and with no significant variation from month to month. In March the mean weight of males rises to 7.2 grams and remains at approximately this level for the remainder of the reproductive period. The oldest males taken in the fall still average over seven grams in weight. The mean weight of females taken in March is 5.64 grams. The mean weight of females taken in April is 6.42 grams and in May is 7.82 grams. The mean weight of adult females then remains at approximately this level through the breeding season. The time of increase in body weight is closely correlated with the time of the maturing of the reproductive tracts in both males and females.

On May 3, 1949, five young *Sorex vagrans* were found in a nest in Greenough Park, Missoula, Montana. These young weighed from 4.4 to 4.7 grams, yet did not have their eyes open. The nest consisted of a ball of dried grass about four inches in diameter with no definite nest cavity. It was in a rotten poplar log

which was about one and one-half feet in diameter and about thirty feet from the edge of a large permanent creek. The mother was not seen.

Dermal glands.—Data on dermal scent glands were available on 106 specimens. These glands, when present, are located on the flanks. Specimens were examined externally before they were skinned, and after skinning, the flesh side of the skin was examined. Of these 106 individuals, fifty-six were males and fifty were females. In immature females there was no evidence of these glands. Of thirty-one sexually mature females taken after March 1, nine had scent glands that were evident on the under side of the skin, but none of the glands were visible externally. In immature males, the scent glands were not apparent externally in specimens captured up to and during January. Of twenty-one immature males captured from June through December, two (one in August and one in December) had glands visible on the flesh side of the skin. Several others had the areas where these glands are normally located marked off by blood vessels, but microscopic sections showed no glandular development. All males taken after January 1 had glands visible on the flesh side of the skin. Of four males taken in February, only one had scent glands that were visible externally. All of the thirty-one adult males taken after March 1 had scent glands that were easily visible externally. In these males the glandular area varied from 2 x 4 mm. to x 5 11 mm. Microscopic sections of glands of mature males and females showed the glands of males to be much thicker and more highly developed than those of females.

Molts.—*Sorex vagrans* has at least two well defined molts each year, one in the spring and one in the fall, and two pelages, the summer and the winter. The winter pelage is darker than the summer pelage, and the two can be distinguished without difficulty. The manner of molt in these shrews is described in detail by Dalquest (1944). In Washington he found shrews in full summer coat as early as March 29, and in winter coat as late as May 16. He found that the fall molt occurred from October 1 to October 9.

In my specimen skins available for study, shrews in the process of molting in the spring were taken from May 25 to June 20. Shrews in the process of molting in the fall were taken from September 10 to November 1. The earliest specimen in the spring with a complete summer pelage was taken on March 25, and the latest in complete winter pelage was taken on June 16. In the fall, the earliest specimen in complete winter pelage was taken on October 7, and the latest in complete summer pelage was taken on October 30. These results are in accord with the statements by Dalquest (1944) and Conaway (1952) that there is a high degree of individual variability in the time that molting occurs.

SUMMARY

This paper is based on a study of 306 *Sorex vagrans* trapped throughout the year in western Montana.

The age of specimens was determined by use of a tooth wear index. There was no evidence that any individuals had lived through more than two summers, and the oldest specimens could not have been more than eighteen months old.

The external body measurements and the skull size, with the possible ex-

ception of the cranial height, do not vary with age in the specimens in the sample. Apparently by the time the young shrews are out of the nest and taken by traps, they have attained their maximum skull size and body measurements. There were no significant differences in measurements of males and females.

The minimum limit in the elevations at which these shrews are found was not determined, but it was found that in Glacier National Park, the upper limit of the Canadian Life Zone, as defined by Bailey (1918), probably marks the upper limit of the common occurrence of these shrews.

Data available indicated that these shrews are most common in damp situations near water, in patches of *Equisetum*, and in grassy meadows.

It was found that these shrews are active both day and night and throughout the year, even during extremely bad weather.

The common associates of *Sorex vagrans* were *Sorex cinereus*, *Peromyscus maniculatus*, *Microtus pennsylvanicus*, and *Microtus longicaudus*. *Sorex vagrans* and *Sorex cinereus* were commonly trapped together in the same habitats, although larger catches of *S. vagrans* were always obtained.

The stomach contents of 137 shrews were examined. These shrews had fed mostly on insects, earthworms, and other small invertebrates, and also some plant material.

The onset of reproductive activity occurs in April in females and in February and March in males. This is accompanied by an increase in body weight in both sexes. The number of embryos in thirty-two females ranged from two to nine with a mean of 6.4. One female showed evidence of having more than one litter per year. With two exceptions, all pregnant or parous females were individuals born the previous year. Males were not sexually active during the breeding season in which they were born. The earliest evidence of pregnancy was in a female collected April 1, and the latest was in a female collected August 8.

Dermal scent glands were found to be evident externally only in mature or almost mature males. Some mature females and two immature males had scent glands visible on the flesh side of the skin. Young females and most young males had no visible scent glands.

Sorex vagrans has a spring molt and a fall molt, a summer pelage and a darker winter pelage. Individual variation in time of molting was great. Spring molts occurred from March to June, and fall molts occurred from September to November.

LITERATURE CITED

BAILEY, V. 1918. Wild animals of Glacier National Park, the mammals. U. S. Gov't. Printing Office, Washington, D. C. 102 p.

BLAIR, W. F. 1948. Population density, life span, and mortality rates of small mammals in the blue-grass field associations of southern Michigan. Amer. Midl. Nat., 40: 395–419.

CLOTHIER, R. R. 1951. Taxonomy of the *Sorex vagrans-obscurus* group in western Montana. Proc. Montana Acad. Sci., 10: 11–12.

CONAWAY, C. H. 1952. Life history of the water shrew (*Sorex palustris navigator*). Amer. Midl. Nat., 48: 219–248.

DALQUEST, W. W. 1944. The moulting of the wandering shrew. Jour. Mamm., 25: 146–148.

———. 1948. Mammals of Washington. Univ. Kansas Publ., Mus. Nat. Hist., 2: 444 p.

Guyer, M. F. 1936. Animal micrology. Ed. 4. Univ. of Chicago Press, Chicago, Ill., 331 p.

Hamilton, W. J., Jr. 1940. The biology of the smoky shrew (*Sorex fumeus fumeus Miller*). Zoologica, New York Zool. Soc., 24: 473–492.

———. 1949. The reproductive rates of somesmall mammals. Jour. mamm., 30: 257–260.

Jackson, H. H. T. 1928. A taxonomic review of the American long-tailed shrews. North Amer. Fauna No. 51, 238 p.

Pearson, O. P. 1945. Longevity of the short-tailed shrew. Amer. Midl. Nat., 34: 531–546.

Rand, A. L. 1948. Mammals of the Eastern Rockies and western plains of Canada. Nat. Mus. Canada Bul. No. 108, 237 p.

Snedecor, G. W. 1946. Statistical methods applied to experiments in agriculture and biology. The Iowa State College Press, Ames, Iowa, 485 p.

Department of Biology, Kansas Wesleyan University, Salina, Kansas. Received June 19, 1954.

DISTRIBUTION OF MICE AND SHREWS IN A COLORADO MONTANE FOREST

By Olwen Williams

Small mammal population and distribution studies have appeared in the literature of ecology with increasing frequency in the last few decades. Many of these have grown out of the expanding interest in ecological problems generally while others have had in large measure a practical purpose. Allen (1949) summarized the varied nature of these projects.

A few studies have been made in the vicinity of Boulder, Colorado. Dondelinger (1942) surveyed the distribution and population of small mammals on Mt. Sanitas near Boulder, discovering some evidence of habitat preference among the animals trapped. Beidleman (1947) investigated the vertebrate ecology of a nearby plains cottonwood river bottom. He found that the dominant mouse in the area was *Peromyscus maniculatus osgoodi*. More recently Glasscock (1950) attempted to determine whether or not habitat preferences influenced the distribution of mice on the mesas south of the city. He found some indication that meadow mice preferred areas that were well carpeted with grass and that white-footed mice were five times as numerous as all others on the mesas.

A host of similar and often more extensive investigations in other parts of the country and abroad have provided much information concerning the activities, distribution patterns, and to a limited extent, the habitat preferences of a number of animal groups (Allen, 1938; Blair, 1940*a*, 1940*b*, 1942; Dice, 1942; Hardy, 1945; Manville, 1949; Gunderson, 1950; McCabe and Blanchard, 1950; Sanderson, 1950; Harris, 1952). Some of these studies were made in an attempt to secure absolute population density figures while others were designed to measure relative populations. Suggestions from these investigations proved useful in the organization of the present study.

In 1950, following an investigation of the home range of the white-footed

mouse (*Peromyscus maniculatus rufinus*) in Pennsylvania Gulch near Sunset, Boulder County, Colorado (Williams, Jour. Mamm., 36: 42–45, 1955), a night of snap-trapping seemed to indicate that the small mammal population of a stream bottom community differed noticeably from that of the ponderosa pine community on the adjacent south-facing slope. Sporadic trapping in other situations in the same general region and the reports of participants in the North American Census of Small Mammals (Calhoun, 1950) from the Rocky Mountain states also seemed to substantiate the fact that, in these mountains, populations of nearby but unlike plant communities were sharply distinct although the distances separating the communities were small. Hence, the present investigation was undertaken during the summer of 1951 to determine the distribution and relative populations of mice and shrews in the various plant communities found in a single forested valley in the Colorado Front Range.

In presenting this material I wish to express my appreciation to Dr. and Mrs. Gordon Alexander for their suggestions and encouragement, for their assistance in the field when the pressure of work was heaviest, and for the use of their cabin in Moon Gulch, Colorado.

Description of the area.—The valley chosen for the study was Moon Gulch, Gilpin County, Colorado. Moon Gulch, which extends southwest from Rollinsville about twenty miles west of Boulder, Colorado, is a typical small mid-mountain valley on the eastern slope of the Front Range (Fig. 1). The narrow valley floor accommodates a small creek and a county road which roughly follows the course of the stream to its upper end at the foot of Jumbo Mountain. The bed of the stream lies at an altitude of about 8500 ft. at the lower

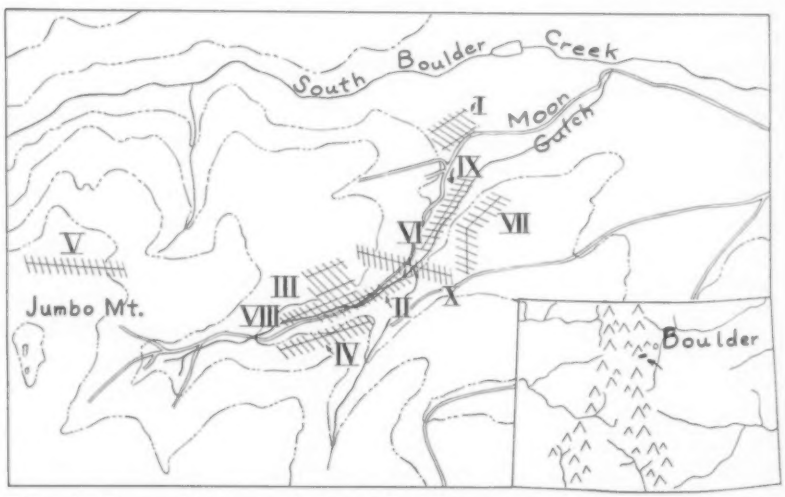


FIG. 1.—Topographical map of Moon Gulch, Gilpin County, Colorado, showing positions of the traplines and transect used in the study. The approximate location of Moon Gulch on the eastern slope of the Colorado Front Range is shown in insert.

PLATE I

General aspect of Moon Gulch. Jumbo Mountain in the background attains an altitude of almost 10,000 ft.

end of the Gulch. The ridges north and south of the valley rise steeply to 9000 or 9500 ft. Jumbo Mountain at the upper and western end of the valley attains an altitude of almost 10,000 ft.

Influenced by slope exposure, soil, available moisture, and the past and present use of the land, a number of distinct plant communities are found in Moon Gulch (Plate I). At the northeast end of the valley an almost pure stand of lodgepole pine (*Pinus contorta*) occupies a low flat ridge. On the southeast slope a stand of low-growing aspen trees (*Populus tremuloides*) has grown up after fire and logging. Where exposure to northwest winds is greatest limber pine (*Pinus flexilis*) dominates this slope. At the point where the south branch of the Creek in Moon Gulch joins the north branch, a small stand of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) has developed on a steep slope well protected from winds by the higher ridges across the valley. The rest of the southeast slope is covered by a mixed forest of lodgepole pine, Douglas fir (*Pseudotsuga taxifolia*), quaking aspen, and limber pine.

About mid-way up the Gulch, the northwest slope supports a relatively pure stand of ponderosa pine. Surrounding this stand is the more frequently encountered mixed lodgepole pine community. In the stream bottom, spruce (*Picea engelmannii*) and fir (*Abies laisocarpa*) dominate with an admixture of willow (*Salix spp.*) and aspen. The only well developed stand of spruce and fir lies at the southwest end of the Gulch at approximately 9500 ft. The trees in this stand have escaped the ravages of fire and lumbering for many years.

In addition to the forest communities there are at present two small meadows in Moon Gulch. One lies on the lower south slope of Jumbo Mountain; the other one occurs about halfway up the valley. Both are used for grazing.

Seasonal changes in the valley are marked. Snow lies deep in the stream bottom and on the protected north-facing slopes until late spring. In contrast, the slopes that are exposed to the west winds may lie bare half the winter because the snow is blown away soon after it falls. Similarly, the combination of warm sun and wind removes the snow cover from south-facing slopes with such rapidity that they, too, rarely are covered for

many days at a time. In summer the exposed slopes support a relatively good cover of grasses and forbs. By the end of the summer this vegetation is noticeably trampled or cropped close by grazing cattle.

Some water is diverted from the creek for irrigation but the volume of the stream is not greatly affected. The most disturbing influence in the stream bottom community is the activity of a flourishing beaver colony which has lived in the valley for years. The colony now maintains a series of dams about halfway up the creek, and at this point the stream is actually a chain of quiet beaver ponds. Near the newest dam and lodge the animals are denuding the adjacent lower hillsides of aspen. Below the area occupied by the colony, a dense tangle of vegetation covers the abandoned dams and deserted lodges. The valley floor is wider here than it is above and is honey-combed by old beaver canals and channels eroded in the silt of the old ponds by spring freshets.

Moon Gulch lies just south of the valley of South Boulder Creek, the route of the Moffat line of the Denver and Salt Lake Railroad. In the past, especially in dry seasons, sparks from engines have started numerous fires that have left their scars on the landscape. The last one swept over Jumbo Mountain in 1938. Although scarred by old fires and pock-marked with prospect holes and old mines, Moon Gulch is now relatively free from human interference and therefore ideal for the present study.

Methods.—Field work for the investigation was carried on from July 7 to September 9, 1951. Following the procedure suggested by Calhoun (1949) two parallel snap-trap lines 400 feet apart were set up in most of the communities selected for study. Each line was 950 feet long and consisted of 20 trapping stations 50 feet apart at each of which three snap-traps were set in likely-looking places within a radius of five feet. The lines were operated for three consecutive nights for a total of 360 trap-nights. In a few of the less extensive communities the lines were set end to end and in one instance a grid of traps was set up to cover the area censused.

During each trapping period an analysis was made of the vegetation in the community. The procedure was to walk along the trapline and record the dominant species in the tree, shrub, and herbaceous layers, noting particularly the nature of the cover and any changes in the aspect of the vegetation from station to station. In each case a collection was made of the characteristic forbs, grasses, and shrubs.

RESULTS

Plot I. *Lodgepole pine community.*—Plot I represented a typical lodgepole pine forest community. It consisted of an open pure stand of lodgepole pine located on relatively level terrain at an elevation of about 8750 ft. near the northeast end of the Gulch. A layer of duff, one-half to one inch deep, covered most of the ground, but in places the coarse gravelly soil was completely bare. The vegetative cover was very scanty, consisting mainly of scattered shrubs and herbaceous plants. Myrtle blueberry (*Vaccinium myrtillus*) and rose (*Rosa sp.*) predominated in the shrub layer; dogbane (*Apocynum androsaemifolium*) and wild pink geranium (*Geranium fremontii*) were the most numerous herbaceous species. The whole area gave the impression of lacking cover and of being singularly free of animal activity.

Traps were set in Plot I on July 7, 1951. They were kept in operation for the next three nights. During most of the period the weather was clear and the average minimum nightly temperature was 44°F. A total of six animals was taken from the area: two red-backed mice (*Clethrionomys gapperi galei*) the first night; one Rocky Mountain phenacomys (*Phenacomys i. intermedius*), and one white-footed mouse the second night; one white-footed mouse and one red-backed mouse the third night. This was a low catch for 360 trap-nights. The three red-backed mice were all trapped at the same station and all of the mice were caught along the second trapline where the ground cover was best.

Plot II. *Upper stream bottom community.*—This plot, at an altitude of 8750 ft. at its lower end, represented a relatively undisturbed stream bottom situation. The site of the census extended upstream from the current scene of beaver activity for a distance of 1900 ft. At this point the stream bottom was hardly more than 75–100 ft. wide, and the sides of the

Gulch rose steeply up to the ridges thus confining the characteristic plant community to a very limited area.

Spruce, fir, alder (*Alnus tenuifolia*), willow, aspen, lodgepole pine and mountain maple (*Acer glabrum*) comprised the tree species. The ground cover was primarily herbaceous. Sixty-two species of grasses and forbs were collected from the spot. Among the most numerous were Colorado columbine (*Aquilegia coerulea*), heart-leaved arnica (*Arnica cordifolia*), paint brush (*Castilleja rhexifolia* and *C. septentrionalis*), cow parsnip (*Heracleum lanatum*), and golden banner (*Thermopsis divaricarpa*). Ten shrubby species completed the count. The most abundant shrubs were kinnikinnik (*Arctostaphylos uva-ursi*), Oregon grape (*Berberis repens*), common juniper (*Juniperus communis*) and myrtle blueberry.

The community was not uniform in aspect. In drier areas myrtle blueberry and common juniper predominated while very wet places supported thickets of willow and alder, and such moisture-loving forbs as the bog-orchid (*Habenaria bracteata*) and mitrewort (*Mitella pentandra*). Under the tall red spruce and fir trees the steep shaded sides of the Gulch were moss-covered and cool.

In this plot two traplines were used end to end. The traps were set July 10 and kept in operation for the next three nights. During this period the weather was cool and damp with minimum temperatures varying from 40 to 48° F.

A total of 20 animals was trapped in this plot: four shrews (*Sorex c. cinereus*), two white-footed mice, two phenacomys, one meadow vole (*Microtus mordax*) and three jumping mice (*Zapus p. princeps*) the first night; one white-footed mouse, one phenacomys, and two jumping mice the second night; one white-footed mouse and three jumping mice the third night. The phenacomys, seldom caught in Colorado, (Williams, 1952) were trapped in alder and willow thickets and near fallen logs partly buried in the deep duff under the spruce and firs.

In striking contrast to the lodgepole pine community first surveyed, a good deal of activity was apparent in the stream bottom community. A number of birds nested in the plot while chipmunks (*Eutamias q. quadrivittatus*), ground squirrels (*Citellus l. lateralis*), pine squirrels (*Sciurus f. fremonti*), cottontail rabbits (*Sylvilagus nuttalli pinetis*), snowshoe rabbits (*Lepus b. bairdi*) and porcupines (*Erethizon e. epixanthum*) were frequently encountered.

Plot III. *Ponderosa pine community.*—Plot III was trapped from July 18 to July 20. This area was located about half-way up the valley on the lower slope of the northwest ridge. The plot thus had a southeasterly exposure. Trapline 1 was set along the lower part of the slope in a mature open stand of ponderosa pine about 200 ft. from the stream bottom. This line was paralleled by a second which lay 400 ft. further up the slope. A conspicuous admixture of lodgepole pine occurred along this second line since the community at this point was in transition to the mixed lodgepole forest that continued on up the ridge. The situation demonstrated the difficulty often encountered in this region in selecting a homogeneous habitat of sufficient size for an adequate census.

The slope of the land averaged 30° to 35°. The soil was coarse, rocky, and dry. The ponderosa pine along the lower trapline formed a typically open stand and the ground beneath supported a fairly good growth of grasses and forbs. Forty-four species of herbaceous plants and ten species of shrubs were collected and recorded for this plot. A number of the shrubs, Oregon grape, chokecherry (*Prunus virginiana*) and squaw currant (*Ribes cereum*), produced fruit attractive to small mammals.

The weather during this trapping period was typical of summer weather in the mountains. The mornings were sunny and warm while the afternoons were cloudy and showery. The nightly minimum temperatures varied from 47 to 54°F. The maximum daily temperature registered during this time was 82°F., a high temperature for the altitude of Moon Gulch. This period comprised the hottest part of the summer of 1951 in the Gulch.

The total catch in this area was lower than that of the stream bottom. A total of 16 animals was trapped: six white-footed mice the first night; six white-footed mice and one phenacomys the second night; three white-footed mice the third night.

Plot IV. *Mixed lodgepole pine community.*—Plot IV was trapped from July 22 to July

25. This plot was located on the lower slope of the south ridge of the Gulch about two-thirds of the way up the valley. Its exposure was to the northwest, and the site was more mesic than that which supported the ponderosa pine community across the stream. The original forest on the slope seems to have been Douglas fir but in 1951 the dominant species was the subclimax lodgepole pine with an admixture of Douglas fir. Limber pine appeared where the soil was poor and where the slope was exposed to the full force of the wind. Aspen grew in the more mesic situations. Since this slope had been disturbed by fire and mining in the past, the community now represented the late successional stage that is characteristic of much of the land in Moon Gulch and elsewhere along the eastern slope of the Front Range.

The ground cover of this plot was more predominantly shrubby than in the other plots studied. Kinnikinnik, juniper, wax flower (*Jamesia americana*), ninebark (*Physocarpos monogynus*), elder (*Sambucus racemosa*), buffalo-berry (*Shepherdia canadensis*), and blueberry were the most abundant. A number of herbaceous species grew in the areas where aspen was dominant. The soil was stony and the slope steep but, save in the patches of aspen, there was more duff on the ground than there had been in the ponderosa pine community that comprised Plot III.

The weather was generally fair during this trapping period. The minimum nightly temperatures varied from 42 to 46°F. The precipitation resulting from the daily afternoon thunderstorms was light to moderately heavy.

Fourteen animals were trapped in this plot: three white-footed and five red-backed mice the first night; one shrew (*Sorex o. obscurus*), two white-footed and two red-backed mice the second night; and one white-footed mouse the third night.

In addition to the small mammals trapped in the plot, jays (*Cyanocitta stelleri*), Clark's nutcrackers (*Nucifraga columbiana*), chickadees (*Penthestes gambeli*), ruby-crowned kinglets (*Corthylio calendula*), pine siskins (*Spinus pinus*), and juncos (*Junco caniceps*) were frequently seen. The mixed lodgepole pine forest seemed more productive than the pure stand of this species.

Plot V. *Jumbo Mountain burn.*—This trapping plot at an altitude of 9600 ft. represented an early successional stage developing after a fire. This fire, which swept the mountain in 1938, destroyed the dense mature lodgepole pine forest that previously occupied the site. Remnants of the forest still stand around the edge of the burned over area. After the fire much of the dead standing timber was cut, but in 1951, on the higher and more inaccessible parts of the mountain, many of the dead trees were still standing.

At an altitude of 10,000 ft. in Colorado, succession after a fire is slow. On Jumbo Mountain spruce, lodgepole pine, and aspen trees were developing. The young pines were three to six feet high but the spruce were much smaller; the aspen did not appear at all along the traplines. The ground cover was predominantly herbaceous. Thirty-three species of herbaceous plants and ten species of shrubs were listed from the plot. Grasses were numerous. The following were recorded: red top (*Agrostis alba*), fringed brome (*Bromus ciliatus*), purple reed grass (*Calamagrostis purpurascens*), June grass (*Koeleria cristata*), Kentucky bluegrass (*Poa pratensis*) and spike trisetum (*Trisetum spicatum*). In this plot the myrtle blueberry was producing fruit in quantity.

The traplines were put into operation on August 1. The weather on that day was sunny and clear but the second and the third days were characterized by recurrent thundershowers. On both the second and the third nights the rain was heavy enough to set off some of the traps. This does not seem to have affected the total catch to any great extent although it may have accounted for the sharply lowered catch of the second night. The minimum temperatures recorded for this period ranged from 50 to 42° F.

The catch was the largest for any of the three-day trapping periods of the summer. Forty-three animals were trapped: 19 white-footed mice and one phenacomys the first night; 10 white-footed the second night; 13 white-footed mice the third night.

The activity in this plot was surprising. Even to the casual observer the animal population appeared greater here than elsewhere. A number of dusky grouse (*Dendrapagus obscurus*), violet-green swallows (*Tachycineta thalassina lepida*), Clark's nutcrackers, rock

wrens (*Salpinctes o. obsoletus*), robins, and white-crowned sparrows (*Zonotrichia leucophrys*) were constantly seen feeding in the area. Once during the trapping period a flock of ten or twelve band-tailed pigeons (*Columba fasciata*) passed through. On several occasions mule deer were seen feeding nearby. Apparently the food supply was substantial and the cover provided by the increasing shrub and herbaceous growth was attractive to a wide variety of animals.

Plot VI. *Grazed meadow.*—One of the two meadows in Moon Gulch was located on the north side of the creek at an altitude of about 8700 ft. It comprised close to five acres of land and had been used for grazing for a number of years. Nine animals were pastured in it at the time the trapping was done. The meadow was well supplied with water and covered with grass but the cattle kept it cropped short making it difficult to identify the specific components of the vegetation. A few well-defined *Microtus* runs occurred in one part of the field where the grass was a little harsher and taller than elsewhere. Innumerable holes and mounds of the pocket gopher dotted the entire five acres.

The trapping technique was here modified because of the limited size of the area available for trapping and because it was apparent that the catch would include the meadow vole which has a relatively small home range (Hamilton, 1937). Instead of the usual two parallel traplines, a grid of 41 stations was set to cover all of the meadow. The stations were set 50 ft. apart in all directions and stakes were driven into the soft ground to mark them. Three traps were set within a radius of five feet at each station. The traps were set on the afternoon of August 5 and were kept in operation for three nights.

The weather was generally fair with light afternoon showers and clear, sunny mornings. The minimum temperatures varied from 48 to 41° F.

The catch from this plot was small even considering the greatly reduced size of the area trapped. Four animals were caught during the three-day period comprising 369 trap-nights: three meadow voles (*Microtus montanus fusus*) the second night; one meadow vole the third night. All were taken within 50 ft. of each other in the well-worn runways. The runs extended for about 100 ft. in one direction and 30 ft. in the other.

Plot VII. *Lodgepole pine—aspen community.*—This plot was situated well up on the southeast ridge at an altitude of approximately 9000 ft. The traplines set up on August 28 were placed end to end but at an obtuse angle to each other to fit the peculiar shape of the census plot. The first line paralleled the ridge along a slope thickly covered with scrubby aspen and limber pine, characterizing a successional community that had recently developed after fire and mining. A few hundred feet below this trapline the community gave way to a dense stand of spruce, fir, and lodgepole pine that continued on down to the stream bottom.

The ground cover consisted mainly of a low shrubby growth of ninebark although five additional species of shrubs were recorded for the plot. Sixteen species of grasses and forbs were collected of which golden banner, spotted saxifrage (*Saxifraga bronchialis*), harbouria (*Harbouria trachypleura*), and Colorado loco (*Oxytropis lambertii*) were the most abundant. The ground was very rocky and the soil thin.

The second trapline followed a power line right-of-way cut through a typical lodgepole pine forest. It represented a noticeably disturbed situation. The ground cover was scanty but a number of aspen and lodgepole pine seedlings had come up in the area. At the time the plot was trapped a number of grasses and forbs were in fruit.

The weather was unfavorable during this trapping period. The minimum nightly temperatures varied from 42 to 50°F. The traplines were set while a light rain was falling. The second night a heavy rainstorm accompanied by hail blew up out of the west and set off two-thirds to three-fourths of the traps. A similar storm the third night snapped three-fourths of the traps.

Despite the adverse conditions, 36 animals were caught: two half-grown female gophers (*Thomomys talpoides*) and 24 white-footed mice the first night; five white-footed mice the second night; five white-footed mice again the third night. It is thought that the abrupt decline in the number of mice caught on the second and third nights reflects the weather that persisted through these days rather than the character of the population.

Plot VIII. *Ponderosa pine community*.—Since the ponderosa pine community trapped earlier in the season was very limited in extent, and since the strong admixture of lodgepole pine along the second trapline had obscured the nature of the results as far as they might be correlated with the vegetation, another attempt was made to sample a ponderosa pine community before the end of the season. Plot VIII was set up not far from Plot III. The census plot was defined by two traplines set end to end about two hundred feet below the first trapline used in Plot III. The lines were set on August 31 and maintained for three nights. Fair weather persisted throughout this period. An early morning low temperature of 40°F. was registered on each of the days but the sun rapidly warmed the open slope. The vegetational aspect of the slope had changed little since the earlier trapping period.

Twenty mice were trapped in this plot: 13 white-footed mice the first night; two white-footed mice the second night; three white-footed mice, one phenacomys, and one meadow vole (*Microtus mordax*) the third night.

Plot IX. *Lower stream bottom community*.—Because the stream bottom community below the present scene of beaver activity seemed so different from that above, it was chosen as the last community to be trapped. Two traplines, extending 1800 ft. downstream from just below the large beaver pond were set on September 4 and operated for three days. The upper end of the first trapline lay along the edge of a wet sedge and grass meadow-like area in which a coarse growth of bluejoint reedgrass (*Calamagrostis canadensis*) predominated. Five hundred feet from the beginning of the first line the situation became more typical of the remainder of the lower stream bottom. Thickets of alder and willow covered the deserted beaver dams. The uprooted trunks of old trees killed when the area was flooded by the beavers were scattered everywhere. Grasses and moisture-loving forbs of many kinds were thriving in the deep black soil. Eighteen herbaceous species including monkshood (*Aconitum columbiana*), firewood (*Epilobium hornemannii*), cow parsnip (*Heracleum lanatum*), and tall mertensia (*Mertensia ciliata*) were listed from the plot, in addition to three species of shrubs, bush honeysuckle (*Lonicera involucrata*), rose (*Rosa* sp.), and buffalo-berry (*Shepherdia canadensis*). The general aspect of the lower stream bottom contrasted strikingly with the dry south-facing slopes of the Gulch.

Twenty-three animals were trapped in this plot: two shrews (one *Sorex c. cinereus* and one *S. o. obscurus*), two white-footed mice, and one meadow vole (*M. mordax*) the first night; five shrews (four *S. c. cinereus* and one *S. o. obscurus*), two white-footed mice, one phenacomys, two meadow voles (one *M. mordax* and one *M. montanus fusus*), one jumping mouse, and one gopher the second night; one shrew (*S. c. cinereus*), one white-footed mouse, one phenacomys and three meadow voles (one *M. mordax* and two *M. montanus fusus*) the third night.

At the cabin the minimum nightly temperatures averaged about 40° F. but on the morning of September 5 hoar frost whitened the grass in the stream bottom at 6:00 A.M. In general the weather was fair with only a little afternoon cloudiness.

Transect.—To serve as a check on the distribution pattern that had become apparent during the season, a transect was set up to complete the study. This transect was laid out from the southeast across to the northwest ridge. It began in the lodgepole pine forest close to the Traverse Gulch road, moved down through the small ponderosa pine community below, and then down into the stream bottom. The line crossed the creek on one of the numerous small beaver dams and led up through the mixed lodgepole pine forest that continued up the northwest ridge. In a few scattered spots aspen became the dominant species but in general the forest was typical of the one that occurs in so many parts of the Gulch, a mixture of lodgepole pine, Douglas fir, and aspen.

The transect comprised 50 stations set 50 ft. apart. At each station three traps were set in likely places within a radius of five feet. Thirty of these stations were set September 7; 20 were set September 8. There was no attempt to do more than sample the area qualitatively. Each station was maintained for one night only. The weather was favorable during this period with sunny mornings and cloudy afternoons. The low temperature recorded during the period was 36° F. on the morning of the second day.

Seven animals were trapped on the transect. One white-footed mouse was caught near the beginning of the line in the lodgepole pine community. Four white-footed mice were trapped in the ponderosa pine community. One white-footed mouse and one red-backed mouse were caught in the mixed lodgepole pine community near the end of the line. No animals were caught in the stream bottom.

DISCUSSION

Shrews were caught in three of the nine areas studied in Moon Gulch. These animals were trapped in the stream bottom and in the mixed lodgepole pine forest on the north-facing slope. In general, the shrews seemed to prefer the more mesic parts of the Gulch. There seemed to be no difference in the two species of shrews trapped with respect to habitat requirement although it is unlikely that they were occupying the same ecological niche (Elton, 1946).

In both the lodgepole pine community and in the stream bottom, the white-footed mouse seemed to maintain itself at relatively low population levels. This was even true in the mixed forest where presumably the mice should find a greater diversity of food and cover. The highest populations of this species were found in disturbed situations, communities that represented fairly early successional stages after a fire or after lumbering or mining. In Plot V, 42 mice were caught in 360 trap-nights. In Plot VII, 34 mice were trapped under the most adverse conditions. These figures stand in sharp contrast to the ones for the other plots. The large size of the population on Jumbo Mountain was interesting in relation to the observations made by Dice (1925). In Charlevoix County, Michigan, Dice found that fire had a disastrous effect on small mammals even if it were only a ground fire that did not destroy the forest itself. He observed that small mammals were abundant in the climax hardwood forest but almost entirely absent from burned over areas ten years after the fire.

It was not surprising to find that the white-footed mouse was the species showing numerical superiority with respect to Moon Gulch as a whole. Rasmussen (1941) found it to be the most abundant small mammal in the montane forest of the Kaibab Plateau in Arizona. Dice (1942) captured the same species at all the stations in the montane belt and found it was restricted to this zone in New Mexico.

The Rocky Mountain phenacomys were caught in such a wide variety of situations in Moon Gulch that it is more difficult to indicate their habitat preference. Five individuals were trapped in the stream bottom, one was caught in the pure stand of lodgepole pine, two were taken in the ponderosa pine community and one was captured in the dry burned-over area near the top of Jumbo Mountain, an unlikely habitat for a microtine. The stream bottom appears to be the community in which they are most frequently found.

The two meadow voles trapped in Moon Gulch, *Microtus mordax* and *M. montanus fusus*, have been recognized as having somewhat different habitat preferences. *M. montanus* has been said to prefer drier ground while *M. mordax* is less limited and has been taken on grassy slopes as well as in marshes and wet woods (Bailey, 1900; Warren, 1942). The present study bore out these observations. Five *M. mordax* were taken in the stream bottom, usually in cold wet places near the water; one was taken on the dry grassy slope of the ponderosa pine community. In contrast the *M. montanus fusus* were trapped in the grazed meadow or in the drier grassy places in the stream bottom. They were never trapped in the willow and alder thickets that grew in the wet soil at the edge of the stream.

The red-backed mice in Moon Gulch were confined to the lodgepole pine and mixed lodgepole forest, in which situations it was the most abundant small mammal studied. Typically it was trapped where the trees formed a continuous canopy overhead and where fallen logs and decaying stumps seemed to provide desirable cover.

Jumping mice were strictly limited to the wetter parts of the stream bottom. In the first trapping period in the stream bottom they were numerically superior to all other species caught there. Only one individual was trapped in the lower stream bottom community, however. It is probable that most of the jumping mice in this plot had gone into hibernation or were inactive during the nights on which the temperatures were close to freezing or below.

The lower stream bottom, with its tangle of fallen timber, deep moist soil, and heavy vegetation should have maintained a good population of this species (Sheldon, 1934, 1938; Hamilton, 1935; Warren, 1942; Quimby, 1951).

Although the results obtained from this study revealed a fairly clear pattern of distribution for the small mammals resident in a montane forest valley, it indicated little concerning the causative factors. In a broad sense a number of interacting environmental factors, both physical and biotic, are assumed to govern an animal's selection of its habitat. The exact role of these factors and the mechanisms through which they operate still demand investigation.

SUMMARY

A total of 3654 trap-nights were set and 190 individuals representing nine species of small mammals were caught in nine different trapping plots and along a transect, yielding some information concerning the distribution and the relative populations of mice and shrews in a single forested valley on the eastern slope of the Colorado Front Range.

Two species of shrews (*Sorex c. cinereus* and *S. o. obscurus*) were trapped in the stream bottom and in a mixed lodgepole pine forest. They appeared to be more numerous in the stream bottom than in the lodgepole pine forest.

The white-footed mouse (*Peromyscus maniculatus rufinus*) was trapped in all of the communities studied. It occurred in greatest number in communities that represented relatively early successional stages after fire, lumbering, and mining. It was the species that was numerically superior with respect to the valley as a whole.

The Rocky Mountain phenacomys (*Phenacomys i. intermedius*) appeared in a surprising variety of habitats ranging from the wet stream bottom to a successional community developing on Jumbo Mountain after fire. The population level of this species was low in all of the communities where it was found, but it did not appear to be as rare as the literature has indicated.

The red-backed mouse (*Clethrionomys gapperi galei*) was trapped in a pure stand of lodgepole pine and in a mixed lodgepole pine community. In both these situations it appeared numerically superior to the other species present.

Two meadow voles (*Microtus mordax* and *M. montanus fusus*) occurred in Moon Gulch. *M. montanus fusus* was limited to the grassy areas in the meadow and drier parts of the stream bottom. *M. mordax* appeared in several habitats from the dry grassy slope of a ponderosa pine community to cold wet places near the stream. Both species seemed to be maintained at rather low population levels.

The jumping mouse (*Zapus p. princeps*) was strictly limited to the stream bottom.

LITERATURE CITED

Allen, D. 1938. Ecological studies on the vertebrate fauna of a 500-acre farm in Kalamazoo County, Michigan. Ecol. Monog., 8: 347–426.

———. 1949. The purpose of mammal population studies. Jour. Mamm., 30: 18–21.

Bailey, V. 1900. Revision of American voles of the genus Microtus. North Amer. Fauna No. 17. 88 p.

Beidleman, R. G. 1947. The vertebrate ecology of a Colorado plains cottonwood river bottom. Unpublished Master's Thesis. University of Colorado, Boulder, Colorado. 351 p.

BLAIR, W. F. 1940a. A study of prairie deer mouse populations in southern Michigan. Amer. Midl. Nat., 24: 273–305.

———. 1940*b*. Home ranges and populations of the meadow vole in southern Michigan. Jour. Wildlife Mgt., 4: 149–161.

———. 1941. Some data on the home ranges and general life history of the short-tailed shrew, red-backed vole, and woodland jumping mouse in northern Michigan. Amer. Midl. Nat., 25: 681–685.

———. 1942. Size of home range and notes on life history of the woodland deer mouse and eastern chipmunk in northern Michigan. Jour. Mamm., 23: 27–36.

CALHOUN, J. B. (editor). 1949. North American census of small mammals. Release No. 2. Rodent Ecology Project. Johns Hopkins University, Baltimore, Md. 67 p. (mimeo.)

———. 1950. North American census of small mammals. Release No. 3. Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine. 136 p.

DICE, L. R. 1925. A survey of the mammals of Charlevoix County, Michigan, and vicinity. Univ. of Mich. Mus. Zool., Occas. Pap. 159: 1–33.

———. 1942. Ecological distribution of *Peromyscus* and *Neotoma* in parts of southern New Mexico. Ecology 23: 199–208.

DONDELINGER, N. W. 1941. The small mammals of Mount Sanitas, Colorado. Unpublished Master's Thesis, University of Colorado, Boulder, Colorado. 55 p.

ELTON, C. 1946. Competition and the structure of ecological communities. Jour. Anim. Ecol., 15: 54–68.

GLASSCOCK, C. E. 1950. Habitat preference of small mammals on Horse and Long Mesas near Boulder, Colorado. Unpublished Master's Thesis. University of Colorado, Boulder, Colorado. 62 p.

GUNDERSON, H. L. 1950. A study of some small mammal populations at Cedar Creek Forest, Anoka County, Minnesota. Occas. Pap. No. 4. Minnesota Mus. Nat. Hist., Univ. of Minnesota. 49 p.

HAMILTON, W. J., JR. 1935. Habits of jumping mice. Amer. Midl. Nat., 16: 187–200.

———. 1937. Activity and home range of the field mouse, *Microtus pennsylvanicus pennsylvanicus* (Ord.). Ecology, 18: 255–263.

HARRIS, V. T. 1952. An experimental study of habitat selection by prairie and forest races of the deermouse, *Peromyscus maniculatus*. Contrib. Lab. Vert. Biol. Univ. of Mich., 56: 1–53.

HARDY, R. 1945. The influence of types of soil upon local distribution of some mammals in Southwestern Utah. Ecol. Monog., 15: 71–108.

MANVILLE, R. H. 1949. A study of small mammal populations in northern Michigan. Univ. of Mich. Mus. Zool. Misc. Publ. 73: 1–83.

MCCABE, T. T. AND B. D. BLANCHARD. 1950. Three species of *Peromyscus*. Santa Barbara, Calif.: Rood Associates, Publishers. 136 p.

QUIMBY, D. C. 1951. The life history and ecology of the jumping mouse, *Zapus hudsonius*. Ecol. Monog., 21: 61–95.

RASMUSSEN, D. I. 1941. Biotic communities of the Kaibab Plateau, Arizona. Ecol. Monog., 11: 229–275.

SANDERSON, G. C. 1950. Small mammal population of a prairie grove. Jour. Mamm., 31: 17–25.

SHELDON, CAROLYN. 1934. Studies on the life histories of *Zapus* and *Napeozapus* in Nova Scotia. Jour. Mamm., 15: 290–300.

———. 1938. Vermont jumping mice of the genus *Zapus*. Jour. Mamm., 19: 324–332.

WARREN, E. R. 1942. Mammals of Colorado. Ed. 2 (revised). Univ. of Oklahoma Press. 330 p.

WILLIAMS, O. 1955. Home range of *Peromyscus maniculatus rufinus* in a Colorado ponderosa pine community. Jour. Mamm., 36: 42–45.

Department of Biology, University of Colorado, Boulder. *Received May 9, 1954.*

OBSERVATIONS ON THE LIFE HISTORIES OF PANAMA BATS

By Prentice Bloedel

Since there is only scanty information on the breeding, feeding, habits, and habitats of all but a few species of tropical bats, the following observations made between February 10 and August 15, 1953, in the region of the Panama Canal Zone, are presented. During the first half of this period, as assistant to Dr. D. R. Griffin, I collected alive as many species of bats as possible for the primary purpose of making recordings of their high-frequency sounds used in echolocation. This work was supported by a contract between The Office of Naval Research and Cornell University. In the course of this work I visited many bat roosts, observed various species both in the field and laboratory, and prepared specimens, some of which are now in the Museum of Vertebrate Zoology. During the last four months of the period I remained in the region studying the fishing habits of *Noctilio leporinus* and did more incidental collecting of other species. I am indebted to Dr. Harold Trapido for pointing out bat roosts in the vicinity, and to Dr. Herbert C. Clark, Director of the Gorgas Memorial Laboratory, for allowing me to use the Juan Mina field station, five miles northeast of Gamboa, as a base of operations during parts of April, May, and August. For accounts of the already existing knowledge of the species listed below see Goldman (Smithsonian Misc. Coll., 69, No. 5, 1920), Enders (Bul. Mus. Comp. Zool., Harvard, 78, No. 4, 1935), and Allen (BATS, Harvard Univ. Press, 1939). Goldman gives a good description of the climate, topography, and vegetation of Panama. Most locality names can be found on any map of the Canal Zone Region.

ACCOUNTS OF SPECIES

Rhynchonycteris naso (Maximilian).—Seven were caught in trammel nets at Borinquen Dam, two miles northwest of Pedro Miguel, on Borinquen Highway, between 6:15 and 7:45 PM on March 23; and one more was shot over the mouth of Rio Mandinga at 8:30 PM on April 22. These bats have a slow, erratic type of flight that is easily recognizable. Two small groups of *Rhynchonycteris* were reported to me as roosting on the lock gates at Pedro Miguel and on a tree trunk near Juan Mina, each group arranged in the characteristic pattern for the species—clinging head down in a line on a vertical surface. While this pattern is found exclusively in it, *Rhynchonycteris* shares with the following two species two other characteristic roosting habits: (1) individuals always hang against a vertical surface, head held well out from that surface with the long forearms extending straight down and below the level of the head; (2) all three species tend to choose open places as roosting sites—*Rhynchonycteris* and *Saccopteryx* in trees, sometimes in open rock recesses or clefts, and *Peropteryx* in open caves or clefts with more than one entrance.

Saccopteryx bilineata bilineata (Temminck).—I found this bat in many places, all of the sort described above. On Barro Colorado Island they roosted on the sides of buildings, at Borinquen Dam in a shaft in the concrete of the dam, on Taboga Island in an abandoned munitions shed and under a rock overhang, in a cleft in a rock bluff near the Pacific entrance to the canal, and at Santa Rosa, Panama, in a cave described below under *Peropteryx*. They were always alert and difficult to approach. Although they were always found in groups, each individual hung singly, a few feet apart from the others.

Saccopteryx (Peropteryx) macrotis macrotis (Wagner).—On May 27, I found a popula-

tion of about 20 in the more open parts of a cavelike series of limestone fissures across the Chagres from Santa Rosa, Panama. Whether or not they were roosting in a cluster I could not ascertain, but four were captured, and all these proved to be females carrying nursing young. A few *Saccopteryx bilineata* were found in the same general part of the cave, and in the darker part there was a large cluster of *Carrollia perspicillata*.

Noctilio leporinus mexicanus Goldman.—Although I found no roosts of this species, their habits were observed in detail in the wild and in captivity and will be the subject of a later paper. They are active all night and were observed fishing over both the Chagres River and Rio Mandinga; they are easily identifiable in flight by their large size, pale color, and slow, deliberate wing-beats, in addition to their fishing activities. In attempts to capture them with silk trammel nets strung over the water, I saw them turn sharply in flight to avoid the net many times. A total of seven were caught during two five-day periods separated by about four months, all in the first two nights of each period. These definite avoiding reactions imply either detection by the bats of threads less than 0.1 mm. in diameter, or that most of the bats that flew over this particular stretch of the river were caught and escaped during the first two nights of each period, and thus learned that the supporting poles, which they could easily detect, were to be avoided.

Noctilio (Dirias) labialis minor (Osgood).—Formerly called *Dirias minor*, this species was placed in the genus *Noctilio* by Hershkovitz (Proc. U. S. Nat. Mus., 99, No. 3246, 1949), who said that "Generic distinction of the small fish-eating bat from the larger . . . is not indicated, and the name *Dirias* should be discarded even as a subgenus." I here follow his inclusive concept of the species *N. labialis*, but retain *Dirias* as a subgenus, on the basis of differences in hind-foot structure and habits, since it is quite definite that *Dirias* is *not* a fish-eater (see below, also Bloedel, in press) while *N. leporinus* is.

Two colonies, both in dry attics, were investigated; one in the church at Pacora, Panama, the other in a house at Juan Mina. Both places were also inhabited by molossids, but the *Dirias* stayed in separate clusters, usually in the more inaccessible parts of the attics. A third colony in a hollow tree near the Chagres River was reported to me. Although this bat is a close relative of *N. leporinus*, nothing but insects have ever been found in its stomach. At Juan Mina we watched members of the species catching insects over the Chagres, flying very low and occasionally touching the water, suggesting a way in which *N. leporinus*' fishing habit may have evolved.

Of the ten collected at Juan Mina at 9:30 PM April 9, as they returned to their roost in the attic, eight were females, all pregnant with large embryos of approximately the same size. Of four females collected at Pacora on March 4, one had a 15 mm. CR embryo, the others were not visibly pregnant. However, these last were kept in captivity for two days before examination, and may have aborted unnoticed. Males were also taken in both roosts. By August 1 the young at Juan Mina were flying, but were obviously smaller and less well furred than the adults.

Chilonycteris rubiginosa fusca J. A. Allen.—About 25–50 of this species were found at Sardanillo Mine, two miles north of Summit, C.Z., associated with over 1000 *Carrollia perspicillata* and *Lonchorhina aurita*. While these two species hung from the roof in single-layered clusters, each *Chilonycteris* was found separately from others of its kind, usually in the densest part of one of these clusters. Some specimens examined externally on February 24 were apparently in late pregnancy, while one of two females taken March 24 was at this stage, and another was not. Males were also present in the mine. Captive individuals refused fruit.

Micronycteris megalotis microtis (Miller).—This species I found either solitary or in small clusters in culverts under roads through forested areas, in the dark underground chambers of the ruins of Fort San Lorenzo, C. Z., and in sheds and houses in El Valle de Anton, Panama, never more than about 20 in one place. These bats always hung from the roof of whatever structure they used as a roost, in loosely aggregated clusters. Captives would not eat fruit and died in captivity.

Micronycteris (Lampronycteris) platyceps Sanborn.—This recently discovered species

(Sanborn, Fieldiana: Zoology, Chicago Nat. Hist. Mus., 31, No. 27, 1949) has previously been recorded only from Trinidad, Venezuela, and dubiously from Nicaragua. Two females were collected April 9 from a sea cave under Fort San Lorenzo, C.Z. They were hanging together, among a large number of *Natalus mexicanus* and *Carrollia perspicillata*, the latter two species hanging in mixed clusters. A few more *M. platyceps* may have been present when I first visited the cave, but were definitely not there when I returned two weeks later.

Lonchorhina aurita Tomes.—At least 500 of these bats were found in Sardanillo Mine, a horizontal shaft about 100 feet long, located in deep forest. The *Lonchorhina* hung from the roof in dense clusters toward the back of the shaft, while an equal number of *Carrollia* occupied the middle and front segments of the tunnel. All four female specimens examined (two taken February 21 and two March 27) were pregnant, with embryos ranging from 15 mm. to 30 mm. CR. Some males were also present in the tunnel. All captives refused fruit.

Macrophyllum macrophyllum (Wied).— Individuals of this species are apparently solitary, or almost so. Two or three were found hanging singly in a sea cave inhabited also by a small population of *Desmodus*, and two were caught in a trammel net on different occasions at Borinquen Dam. This has been considered a rare species (Goldman, *op. cit.*) and more than a few are apparently never found in one place. My only captive died after two days with fruit available.

Phyllostomus hastatus panamensis J. A. Allen.—*Phyllostomus* was found night-roosting under bridges and in a shed on Borinquen Dam; in the daytime I found one in the Pacora church, and about 20 in a monument tower on the highway from Panama City to Tocumen Airport. In all these places the bats hung from the highest place available, while other species occupied lower roosting sites. These other smaller species showed no apparent fear or caution in the presence of *Phyllostomus*, either in the wild or in captivity; their equanimity is surprising in view of the known predatory habits of *Phyllostomus*. When such species as *Carrollia perspicillata* or *Glossophaga soricina* were placed in a cage with one of these large bats, the former were apparently completely unconcerned; the *Phyllostomus* killed them simply by sidling up and biting them in the head. However, once when a dead bat was placed on the floor of the cage, a *Phyllostomus* dropped on it with wings outspread, apparently as if it were reacting to a live animal. Captives always ate their animal food while hanging from the top of the cage, using thumbs and wrists to manipulate the carcasses, and confining them with ventrally outstretched wings. Food taken in captivity included mice, fish, lizards, bats, live moths, and fruit. At Juan Mina, a flock of about 30 came several times at twilight on days when there had been late afternoon showers to catch swarming termites around a large solitary mango tree.

Glossophaga soricina leachii (Gray).—I found this bat many times in culverts, houses, caves, and tunnels, always in dark and sheltered places. It was usually solitary or in small groups, most often associated with *Carrollia perspicillata*. One captive female aborted a large embryo on February 17. According to Dr. Griffin, captives can be trained to hover over and drink from a flat dish of sugared water or watered honey.

Carrollia perspicillata azteca Saussure.—By all criteria the most common bat of the neotropical region, *Carrollia* was usually found in dark places—abandoned houses in the forest, caves, mines, culverts, and hollow trees. Individuals may be found solitary or clustered in colonies of as many as 1000. They thrived for several months in captivity on a diet of bananas and mangoes, but eventually died after losing most of their hair. In a few large colonies, at different times of year I found only a few females with young, and gained the impression that this species may breed at all times of year.

Uroderma bilobatum Peters.—I observed these bats only in their palm-leaf tents at Summit Experimental Gardens, and can only confirm their already known habits. (Allen, *op. cit.*). In the latter part of March most females have nursing young, and are roosting in clusters of 20 to 40, while the males are separated from them, usually solitary or in small groups of from 2–5. The females are active throughout the first half of the night at least, returning during this time occasionally to the young, which are left hanging in the palm-leaf shelters. When feeding on small palm fruits (unidentified) they show surprising skill in

manipulation with their wrists and thumbs, turning the fruit and gnawing at the rind until only the central nut remains. In captivity they survived well on bananas and other fruit, except females with young, which usually died soon after capture.

Artibeus lituratus palmarum (J. A. Allen and Chapman).—These bats were found only in buildings, usually in fairly well-lighted places, hanging from rafters in rows of from 5-25. *A. lituratus* may be a tree-roosting bat like its smaller relatives, but it is not known to cut palm leaves to make a shelter for itself, as *A. watsoni* does. Four individuals found in an abandoned house at Summit had dropped many espave beans below their habitual roosting place. Three of these were females, each of which gave birth to one young in captivity during the last three days of March. This species also becomes debilitated and hairless after a few months in captivity on a diet of fruit alone.

Desmodus rotundus murinus Wagner.—The true vampire has been well studied previously and I observed nothing new of its habits. It is not common in the region of the Canal Zone, but can be found in a sea cave near Arraijan and on Taboga Island, Panama. Vampires have survived and reared young in captivity.

Natalus mexicanus saturatus Dalquest and Hall.—A large colony of bats of this species was found in the sea cave under Fort San Lorenzo. Fourteen collected alive on April 7 were all females, and all either aborted large embryos or were still pregnant when killed. Thus this species seems to be one in which there is synchronized breeding and segregation of the sexes during the time when the young are born.

Myotis nigricans nigricans (Schinz).—A few solitary males were found on window screens or under eaves of buildings on Barro Colorado Island on March 24. About 50 (not sexed) lived in a cluster hanging from the ridgepole in the attic of the Pacora church. I observed the latter on March 4 and March 23, and found no young present.

Tadarida yucatanica (Miller).—About 1000 comprised most of the bat population of the Pacora church attic, a hot, dry, almost completely dark space. The *Tadarida* hung from the sides of the floor joists and often were piled up on the floor between the joists. None hung from the roof, as did the small cluster of *Myotis* listed above. Dry dung was as much as 6 inches thick in places where the bats were most concentrated. There were no young bats or pregnant females among the specimens examined, all taken during March.

Molossus bondae H. Allen.—A small colony lived in the house at Juan Mina with about the same number of *Dirias*. A few naked, but flying and almost adult-sized, young were noted in early August, when a particularly hot and rainless day drove the bats to crawl out of the attic onto the outside of the house during the middle of the day.

Molossus coibensis J. A. Allen.—These bats were found in a few houses and were often seen flying just before dusk, from about 6:15 onward. On the dry southern side of the Isthmus, they seem almost as common as *Carrollia*, particularly in houses and around towns.

Eumops abrasus milleri (J. A. Allen).—One small colony of not more than ten individuals was found in the attic of a house in Gamboa, living just under the roof in a rather inaccessible corner. All four species of molossids that I encountered I found only in warm, dry places, where they usually did not hang head down but tended more to crawl into cracks and small recesses. When disturbed, they almost never fly, but try to escape by running on all fours.

Museum of Vertebrate Zoology, University of California, Berkeley 4. Received July 27, 1954.

OBSERVATIONS ON THE MEXICAN FREE-TAILED BAT, *TADARIDA MEXICANA*

By Philip H. Krutzsch

The Mexican free-tailed bat (*Tadarida mexicana*) ranges over much of western North America and is common and easily obtained. In spite of the wide distribution and ease of collection of these bats, data regarding their life-history are fragmentary.

The observations presented here were gathered as part of a general study of the bats of southern California. Field work was done intermittently through most of the years 1938 to 1943 and in the summers (June to September) of 1946, 1948, 1949, and 1951. A planned life-history study was not made. However, a considerable amount of new information regarding this species has been recorded. Most of the observations here reported upon were made in San Diego County, California and unless otherwise noted all geographic localities are in this area. I wish to acknowledge the assistance given by Drs. Richard W. Neil, Carl Engler (1938–1943), and Keith L. Dixon (1946).

Mexican free-tailed bats most often inhabit the Lower and Upper Sonoran Life Zones, however, they are not uncommon in the Transition Zone. In San Diego County these bats are most abundant at lower elevations, particularly on the western slopes of the mountains. *Tadarida mexicana* has a wide habitat tolerance and occurs in cultivated areas, on chaparral flats, on rocky hillsides, in open forests of yellow pine and black oak, and on juniper covered slopes of the eastern foothills.

The free-tailed bats utilize a wide variety of diurnal roosting sites, selecting hiding places in both man-made and natural situations. These bats have been found roosting in the following man-made structures: wooden bridges, warehouses, barns, wooden and stucco houses, schools, behind signboards, milking sheds, attics, beneath tile roofs, and in open garages. Natural retreats are less often recorded, possibly because of the difficulty of locating such sites. Bats were found to frequent cracks and crevices in rocks but were not seen in natural caves. It is likely that *Tadarida* was originally a crevice dwelling species, as resting places in cracks, narrow spaces, and small holes seem to be most often selected by these bats.

The colonial populations may vary from gatherings of 10 or 20 individuals to those numbering in the thousands. The same roosts are often occupied for several seasons. It is our experience that a few places temporarily inhabited were populated by solitary males or single parous females. Temporary hiding places often are not populated on successive days. At Felecito Park on August 29, 1946, a single male was taken from its roosting place in a narrow space behind a signboard; on July 12, 1948, another was found in a space between two supporting beams of a bridge at Green Valley Falls; and on June 1 1949 a third was obtained from its diurnal retreat between the shutter and window screen of a church at Santee. Several visits at later dates to these sites failed to uncover additional bats. Because the sexes do not usually segregate during the

summer season, males are not forced to seek temporary roosts, therefore, solitary individuals are not frequently encountered.

Numerous observations on regularly occupied roosts show that these roosting sites have certain factors in common, and presumably these characteristics are requisite for occupancy. Bats select places that are dark or dimly lighted, not frequently disturbed, containing numerous cracks and crevices, and where summer temperatures are high.

The strong, penetrating, musky odor of these bats is often detectable several hundred feet from the colony and possibly plays an important role in attracting individuals to the roosting site. At San Marcos the attic of a church served as the diurnal roost for a large number of these bats. Because of ease in observation this colony was more closely watched than were the other colonies (25) known in the San Diegan area. Visits were made to this roost at intervals during the years 1939, 1940, 1941, 1942 and 1943. In this time the attic also served as the diurnal retreat for bats of the genera *Eptesicus* and *Antrozous*; however, each kind of bat occupied a specific area in the roost. The attic, a large room, was incompletely partitioned into three smaller rooms. These rooms were dry and dark and the musky smell of the bats was nearly overpowering. Ventilator openings made the entire space easily accessible to the bats from the outside, and it was through these ports that most of the bats (all species) gained access to the roost. Some individuals (*Tadarida mexicana*) roosted on the ridge pole that extends the entire length of the room, but most of the free-tailed bats were found in the low-ceilinged, central portion where they clung one upon another often to several layers. After the young were born the adults were confined to the ends of the room near the ventilator openings, leaving the young to occupy the central part. The attic was utilized during the months April through November, but the numbers of individuals present varied seasonally. The population was greatest from April through September and reached its maximum in mid-June, when the young were born. After September, when the young reach adult size and when the fall dispersal begins, the number of individuals in the attic gradually decreased, and by the middle of November the roost was deserted.

A seasonal estimated population summary for the Mexican free-tailed bats roosting in the San Marcos Church in the year 1941 follows: April 4, 300 (adults); April 25, 400 (adults); May 7, 500 (adults); May 16, 500 (adults); June 15, 1,000 (young and adults); July 2, 1,000 (young and adults); July 5, 1,000 (young and adults); July 9, 1,000 (young and adults); July 15, 1,000 (young and adults); August 5, 1,000 (young and adults); August 15, 800 (young and adults); September 15, 300 (adults in appearance); October 2, 8 (counted, adults in appearance); November 12, 210 (counted, adults in appearance); January 12, no bats.

Tadarida frequently is found with other species of bats. Usually it is in the same roosting site but separate from these different species. *Myotis yumanensis sociabilis*, *Antrozous pallidus pacificus*, *Eptesicus fuscus pallidus*, and *Corynorhinus rafinesquii pallescens* were found to associate with *Tadarida mexicana*. At other places in California various species of *Myotis* (*volans*, *thysanodes*, and *californicus*)

have been found to occur with *Tadarida*. *Tadarida*, *Eptesicus* and *Antrozous* were most commonly together. These bats seemed to live successfully and peacefully in their separate areas within the roosting place. On several occasions single *Tadarida* were found roosting with large groups of *Myotis yumanensis*. In each instance the free-tailed bats were young individuals. *Corynorhinus* and *Tadarida* were found in the attic of a milking shed on the grounds of the Edgemore County Farm at Santee; the free-tailed bats were in crevices and the lump-nosed bats were hanging in the open.

The adults of the two sexes are found together throughout the year. However, in the season when young are being reared there seem to be fewer adult males in the colonies, and perhaps at this time there is a partial separation of sexes.

Little is known of the reproductive behavior of *Tadarida mexicana*, but the data available indicate that the habits of this species are similar to those of *Tadarida cynocephala* (Sherman, Jour. Mamm., 18: 183–184, 1937).

The testes of males collected in the summer were abdominal, small (2.0 to 3.0 mm.) and presumably inactive, whereas those of males taken in the spring were partly interfemoral, enlarged (4.0 to 5.0 mm.) and were, therefore, thought to be producing sperm. If an increase in the gross size of the gland is a valid criterion for indicating function then males presumably are capable of inseminating females in the spring. Sherman (*loc. cit.*) found individuals with small testes, prostate, and unworn teeth in all months of the year; these he thought were sexually immature. Hartman (Quart. Rev. Biol., 8: 191, 1933) found that in Texas *Nyctinomus* [= *Tadarida*] *mexicana* breeds in the spring and is in anoestrus for the remainder of the year.

The Mexican free-tailed bat normally has a single young but there may be two. Several pregnant females with two embryos each were obtained, but the vast majority of females examined had only one embryo. The young in different colonies may show variation in development, and variation, to a lesser degree, is also evident within a single colony. However, development is not so markedly variable as in some of the vespertilionid bats. It is probable that when variation in the size of the young occurs it is due to the difference in the date of copulation (insemination), ovulation presumably occurring shortly after copulation, rather than differences in the date of ovulation, as is true with fall copulating and spring ovulating (hibernating) bats.

The majority of young are born by mid-July. The following observations were made in 1940 on bats obtained from the attic of the San Marcos Church. The uteri of two individuals taken on April 3 were swollen and the bats were presumed to be pregnant; a bat taken on April 28 contained a single 3 mm. embryo; another collected on May 3 had a 5 mm. embryo; and another taken on May 29 had a 20 mm. embryo. A female taken on June 2 had a 19 mm. embryo; one on June 4 contained an 18 mm. embryo; and 25 mm. embryos were found in several individuals taken June 23 and 25. A female taken on July 4 contained a 29 mm. embryo, and one taken on July 8 held an embryo that measured 28 mm. On July 9 lactating females and naked young were found; the young varied somewhat in size but their birth dates could not have spanned

more than three or four days. Perhaps there were females that had not yet delivered, but a cursory search disclosed none. These data indicate that the period during which young were in utero in the San Marcos colony, at least for 1940, extended from April 3 to July 9, approximately 100 days.

The development of the young is rapid, and they become independent of parental care early. On July 20, 1946, lactating females and furred young were taken at Santee; these young were unable to fly. On August 8 and 9, 1946, lactating females and nearly adult-sized young were taken at the Red Mountain Ranch, four miles east of Fallbrook; these young were all able to fly. In the Bush Citrus Products warehouse at National City on August 14, 1946, lactating females and large young were collected. The young were able to fly and approached adult weight. A series of ten adult females and males averaged 11.4 grams and a similar series of young averaged 9.3 grams. On August 29, 1946, at Lake Hodges an immature male was taken from a cluster of *Myotis yumanensis*. On the same day 30 bats were taken from a bridge over San Pasqual Creek; these consisted of 15 nearly full grown young and 15 adults. All of the bats were of similar size but differed in weight; 15 adult males and females averaged 10.7 grams, as compared to an average weight of 9.7 grams for 15 juveniles. The young were also separable as to age on the basis of their elongate finger joints. Females taken on September 4, 1946, had ceased to lactate and young bats were distinguished by their elongated finger joints, shorter fur, and smaller body weight.

It is interesting to note the lack of parental care of the young. Females were never found with young attached. At the several roosts observed the young were clinging together in large masses separate from the adults. These young bats never seemed to cease squeaking and moving; perhaps the warmth of such close proximity prevents inactivity. At 12:10 PM, June 28, 1939, at San Marcos a temperature of 41°C was obtained by placing a thermometer in a mass of young. The room temperature was 33.5°C. A measurement at 8:30 PM of the same day, disclosed that the room temperature had decreased to 25°C. The temperature of the young at 8:30 PM was 40°C. The young were active, constantly chattering and crawling about, which may account for their high body temperature. On July 5, 1940, again at San Marcos, the temperature was 42°C at 12:30 PM, and room temperature was 35°C. At other roosting places, under tin roofs, in attics, and under tiles, room temperatures also were high. Nevertheless, such places are favorite sites for *Tadarida* and the high temperatures may play a significant role in the rapid growth of the young of these bats.

The young apparently are fed at night after the adults have foraged. On July 9, 1941, at the San Marcos Church, adult females were found among the group of young at 12:05 AM and several of the young were found to have stomachs distended with milk.

Night resting, a habit of many species of bats, is not especially well developed in *Tadarida mexicana* which apparently does not habitually retire to sheltered places other than their own roosts to "hang up" and rest. The term habitually is used because on occasion they have been found at rest in a sheltered spot normally frequented for night roosting by other species of bats. At Lakeside

the front porch of the grammar school served as a night resting station for *Eptesicus* and *Antrozous*. On the evenings of August 15 and 30, 1951, several *Tadarida* were found on each of two visits and were in company with numerous pallid bats. On several occasions in the summer of 1946, free-tailed bats were found night roosting along with *Myotis yumanensis* in the corridors of the biology building at San Diego State College. An open milking shed at Santee normally favored by *Antrozous* sheltered a single male *Tadarida* at the time of our visit on the evening of August 20, 1946.

The Mexican free-tailed bat usually begins foraging soon after sunset and continues feeding until just prior to dawn. The long, narrow wings and the straight, rapid flight of the foraging *Tadarida* makes it easily distinguishable from other species of bats. Foraging routes can be at various heights, depending on the vegetation, terrain, and prey. At Little Murry Dam on March 31, 1942, freetails first appeared at 7:25 PM approximately ten minutes before sunset, and the bats were clearly visible in the early evening as they foraged over the chaparral hillsides and the stream bottom. Hunting was at heights from 15 to 30 feet above the ground, and presumably pursuits of insects were marked by quick changes in direction of flight. Bats were not seen to drink, although their foraging flight carried them over and near the water surface. On May 11, 1941, at El Monte Oaks Park, *Tadarida* were first observed, well before darkness; the bats were high, well over 100 feet above the valley floor. As darkness increased they flew lower, feeding about the top branches of the live oak trees. On September 11, 1947, at Chimney Camp they were on the wing at 7:05 PM, flying low over an open meadow bordered by willow, alder, sycamore and live oak. They flew fast and usually in a straight line; changes in course were to the sides and, less frequently, shallow dips earthward. Several continuous observations made at the San Marcos Church from evening until daylight indicate that *Tadarida* may be away from the roost from dusk until dawn; presumably foraging occurs at intervals throughout this period.

There is a rhythm of diurnal activity in the colony that seems to be influenced by temperature. Activity begins in the norming in warm weather, whereas, on cool or cloudy days bats remain quiet and inactive until it becomes warmer. When bats are awake they carry on an incessant squeaking and chattering which is audible for a considerable distance from their roost. Bats are continually moving and scrambling around, often crawling over the backs of their fellows. Activity seems to continue most of the day, but not all individuals are active at any one time. Late in the afternoon most bats are quiescent, arousing to full activity shortly before sunset. Light intensity seems to be part of the trigger mechanism which brings about the evening appearance of *Tadarida*. On foggy or cloudy evenings, when twilight is short, freetails are on the wing before the normal time of sunset. On clear evenings they begin to emerge shortly after sunset. A summary of observations at San Marcos Church made from 7:00 PM to 5:00 AM on July 9, 1941, provides the following data: 7:00 PM, estimate of 1000 bats in roost, a few bats leaving roost, bats flying in large numbers in attic, inside temperature 25°C; 8:00 PM, more bats leaving roost, bats still

flying in attic, inside temperature 25°C, estimate 300 bats out; 9:00 PM, moon out bright, bats still leaving roost, they chattered shrilly as they took wing, estimated 600 bats out; 10:00 PM, moon still bright, few clouds, bats still leaving roost, many flying about in attic, young active and calling loudly, inside temperature 22°C; 10:50 PM, many bats still leaving; possibly 200 left in roost; 12:00 midnight, clouds beginning to obscure the moon, inside temperature 19°C, some adults back hanging with young; 1:00 AM, bats all out except few with young, inside temperature 19°C; 2:00 AM, most bats out; 3:00 AM, most bats out; 4:00 AM, sky cloudy with high fog, bats have started to return, some flying inside roost, many entering; 5:00 AM, bats are back in large numbers, inside temperature 18°C.

The Mexican free-tailed bat feeds on insects. Droppings collected from beneath roosting places contained finely masticated and unidentifiable insect parts. Feeding apparently is done entirely on the wing, and it is logical to assume that flying insects form the major part of their diet. Storer (Jour. Mamm., 7: 88, 1926) gives a detailed report on samples of guano collected from roosts of *Tadarida* in Texas. He found that well over 90 per cent of the total insects consumed were moths.

In San Diego County specimens of *Tadarida mexicana* have been taken in all months except January. Free-tailed bats are abundant from March through September; the frequency of their occurrence and their abundance drops off until they disappear completely in mid-December. Places where bats are found in large numbers during summer months are deserted in winter. Perhaps these bats seek more secluded places for winter roosting.

Individuals of *Tadarida* collected in the summer of 1946 were carefully examined for ectoparasites. Most of the bats that were roosting singly were free of infestation; however, bats collected from colonies were usually heavily infested. Only a single collection of ectoparasites was saved; these parasites were taken from bats that were found beneath a bridge two miles east of San Pasqual. Numerous nymphal mites of the subfamily Liponyssinae and several fleas (possibly *Myodopsylla*) were obtained. The mites were on the membranes and the fleas were on the furred parts. Other ectoparasites, such as flies, bedbugs, lice, and ticks often associated with bats were not found.

Instances of vertebrates preying on bats are comparatively rare. Snakes and birds have been most often cited as predators. Several of the barns known to harbor colonies of freetails also serve as nesting sites for barn owls. In each such roosting place pellets from the owls were collected and analyzed. More than 300 pellets were examined and evidence of predation on bats was found in only one instance. A radius and part of a skull were uncovered in a fresh pellet taken from beneath a nest at Santee. At other places predation on *Tadarida* by raptorial birds has been reported. R. M. Macy and R. W. Macy (Jour. Mamm., 20: 252, 1939) observed red-tailed hawks attempting to catch bats. The bats were returning to their diurnal roost at sunrise. K. Stager (Condor, 43: 137–139, 1941) wrote a very vivid description of predation on a colony of *Tadarida mexicana* by duck hawks. These birds preyed on the bats when the

colony emerged in the evening and again in the morning when the bats returned to their roosts.

Summary.—*Tadarida mexicana* is a colonial species and occupies diurnal roosts in both man-made and natural places. Such roosting sites are in dark or dimly lighted places, which have numerous cracks and crevices and usually, in summer, are excessively warm. Mexican free-tailed bats often frequent the same general roosting places utilized by other species of bats (*Myotis yumanensis, Antrozous pallidus, Eptesicus fuscus* and *Corynorhinus rafinesquii*).

Males and females are found together throughout the year, presumably insemination occurs in the spring, and normally there is a single young following a gestation period of not over 100 days. Parental care of young seems to be restricted to nursing; babies and adults often occupy separate places in the roost.

There is a rhythm of diurnal activity which seems to be influenced by temperature; bats are more active on warm days. Light intensity is thought to influence the time of evening emergence, as bats appear earlier on cloudy evenings and later on clear evenings.

Tadarida mexicana is known to harbor ectoparasites; those in colonial gatherings are more highly parasitized than are those roosting singly. These bats are rarely preyed upon; only owls and hawks have been reported as predators.

Department of Anatomy, 300 Pennsylvania Hall, University of Pittsburgh, Pittsburgh 13, Pennsylvania. *Received May 6, 1954.*

SURVIVAL AND MOVEMENTS OF BANDED BIG BROWN BATS

By James R. Beer

Between 1932 and 1951, over 67,000 bats have been banded in North America (Mohr, 1952). This gives some idea as to the lack of data for any given species since there are some 36 species of bats found in the United States. The number of big brown bats banded has not been large. The literature based on these banding data contains some instructive information as well as some controversial points.

Griffin (1940*a*) came to the conclusion that big brown bats winter relatively close to their summer quarters while Rysgaard (1942) was of the opinion that they traveled many miles between winter and summer quarters. The greatest distance recorded between summering and wintering localities by Griffin was ten miles while Rysgaard reasoned that since few big brown bats were collected near the wintering quarters in the summer and a few were collected at long distances from known suitable wintering places, they must normally make quite long migrations. Reynolds (1942) recorded one adult female wintering 3.5 miles from the summer roost and Hitchcock (1949) reported two big brown bats banded in winter as being reported at 16 miles and "within a few miles" of the point of banding. Hitchcock also reported that three bats banded in the summer were subsequently recovered in buildings during the winter—all within five

TABLE 1.—*Movements of big brown bats banded in caves during hibernation*

Number	Sex	Date Banded	Date of Recapture	Distance Traveled in Miles	Habitat at Time of Recapture
43-147660	♂	Nov. 22, 1949	Dec. 24, 1952	3.2	Residence
48-288	♂	Feb. 5, 1948	June 15, 1948	.5	Warehouse
48-579	♂	Feb. 14, 1948	June, 1948	8.5	Residence
48-136023	♀	Nov. 22, 1949	Jan. 2, 1950	1.2	Outside
49-121817	♂	"	Jan. 31, 1950	.6	Cave
49-121850	♂	"	Aug. 3, 1952	33.–	Residence
49-148017	♂	Jan. 22, 1950	May 22, 1950	.6	"
49-150416	♀	Feb. 22, 1951	April 24, 1951	6.0	Airplane Hangar
49-150479	♂	Jan. 31, 1950	Dec. 2, 1950	.6	Cave
49-150493	♂	Feb. 5, 1950	"	19.–	"
49-150685	♀	Nov. 12, 1950	Jan., 1952	1.6	Residence
49-150732	♂	Nov. 2, 1950	Nov. 30, 1950	.6	Cave
49-150789	♂	Nov. 9, 1950	Dec. 2, 1950	61.–	"
49-175107	♂	Nov. 30, 1950	Feb. 2, 1952	.6	"
49-175411	♂	Feb. 22, 1951	July, 1951	5.5	Residence
49-175415	♂	Jan. 20, 1951	Nov. 1, 1951	4.0	"
49-175439	♂	Feb. 22, 1951	Aug. 8, 1951	6.4	"
49-175479	♂	Jan. 20, 1951	June 25, 1951	1.4	"
49-175583	♂	Feb. 5, 1951	Feb. 14, 1951	.6	Cave
49-175643	♂	Feb. 22, 1951	March 13, 1951	.5	Residence
49-175648	♂	"	Aug. 24, 1951	12.8	"
49-175661	♂	April 7, 1951	May 28, 1952	5.6	"
49-175930	♂	Feb. 2, 1952	Oct., 1953	8.8	Hotel
49-175939	♂	"	Feb. 5, 1954	2.2	Residence
49-177131	♂	Jan. 11, 1953	Aug. 11, 1953	1.8	"

miles of the point of banding. All workers will agree with Hitchcock's (1949) statement: "the number of banded bats recaptured away from their places of hibernation has been disappointingly small."

This study of the survival and movements of big brown bats, *Eptesicus fuscus* (Beauvois), began during the winter of 1940–41 when G. N. Rysgaard and W. H. Elder started banding cave bats in Minnesota and Wisconsin, respectively. Rysgaard examined all of the caves then known in Minnesota and during his one winter's work banded about 312 big brown bats. During the winters of 1940–41 and 1941–42, Elder banded about 113 bats of this species. In the winters of 1946–47 and 1947–48 Frederick Greeley and I banded some 499 more big brown bats in southern Wisconsin. From the winter of 1949–50 through the winter of 1952–53, I banded some 2947 big brown bats in southeastern Minnesota. The returns from these 3871 bats through the winter of 1953–54 form the basis for this report.

Movements.—During the period of this study 25 bats have been reported from areas other than where they were banded (Table 1). An examination of these data shows that most of the foreign recoveries were but a short distance from the point of original capture. These returns varied from 0.5 mile to 61 miles with the average distance traveled being about 7.4 miles. There was little

difference between the average distance for winter to summer and winter to winter locality movements. All 12 of the summer recoveries were at localities other than the one from which the bats were originally banded, while only 13 of the 992 bats rehandled in the winter were from areas other than the one in which the bat was first banded. Only 7 of the 251 bats retaken after one or more years were taken away from the point of original capture.

The movement of an animal with the mobility of a bat from winter to summer quarters of over 30 miles is not surprising. The November movement of a bat from a place known to be suitable for wintering to another such place over 60 miles away is more difficult to explain. Griffin (1940*a*, 1945) has reported such movements for the smaller *Myotis lucifugus* in New England. While there is considerable variation in the distances traveled by these bats it is probable that the big brown bat normally confines its activities to a relatively small area.

At present we have no definite knowledge of how the migration from summer to winter quarters takes place but the fact that bats show up in houses most commonly in August and September, and that they may show up in small numbers at winter caves as early as the first of September, suggests that this movement is probably leisurely and possibly circuitous. The big brown bats do not seem to go to the localized wintering caves in large numbers until severe weather forces them out of the less protected places. In Minnesota, a relatively stable wintering population of bats is not reached until the first week in December.

Most papers dealing with the movements of bats mention that when one enters a cave it is usual to see one or more bats in flight. This activity has been frequently noticed during this study. In order to obtain more information on this activity three bats were placed in an activity recording apparatus in constant temperature chambers (held at 5°C) for a period of 20 days. Eight, 10, and 11 days were spent in hibernation between periods of activity. They were then active for about two hours before going back into a state of torpor. Four bats, all males, were observed to move from one cave to another during the winter (Table 1). Three of these made their movements at such a time that it seems improbable that the movement was part of the migration to permanent winter quarters. There are two possible explanations for these movements. The first is that they leave due to the disturbance caused by banding and the second that these are normal movements. This species normally becomes active during banding and relocates after being released. It is not uncommon to see bats fly to the entrance of the cave and turn back abruptly as they hit the sub-freezing temperatures of the outer air. Within an hour after the bats have been released very little activity can be observed. It seems probable that the cave to cave movements are normal and may facilitate breeding since this species often hibernates in small numbers in odd places. Copulation apparently takes place at any time during the winter. This species may use more than one place in which to spend its winter hibernation. Without intensive studies it is difficult to estimate what part of the population is involved in this behavior.

Many of the bats that are taken in the original cave two or more years after banding are not taken during the intervening years. This appears to be due to

the absence of the bats from the original cave since the caves worked lend themselves to a fairly complete recovery of the bats present. The data seem to indicate that some bats may not spend consecutive winters in the same cave and that others may divide their time between two or more wintering places.

Survival.—Most of the studies pertaining to the survival of bats in North America have stressed maximum longevity and the causes of mortality but have not discussed mortality rates. Eisentrout (1947) in Europe reports annual losses among *Myotis myotis* to amount to about 40 per cent per year with striking regularity.

The following analysis is based on all bands returned one or more years after the original capture and is thus a combination of mortality and survival data (Hickey, 1952). The life table constructed is thus a synthetic one and represents a theoretical population.

There are several factors that may affect the interpretation of the data presented here. All of the bands except those used by Elder and Rysgaard were placed on the wing and may have been the cause of some mortality. It seems probable that there is very little loss of this nature after the first year. This would appear to eliminate most of this possible error in the data presented here. Some of the bands may have been lost due to chewing by the bats. Bands that do not fit properly will be damaged in this manner so they cannot be read (Banfield, 1948). One band that was presumably three years old was so badly chewed that it was nearly ready to drop off. It could not be read and was thus lost to this study. Most of the bands reported were retaken by persons interested in bat banding and the effort involved in obtaining bands varied from year to year. This, however, was partially compensated by several years' bandings being involved.

The populations from which these data were gathered appeared to be declining during the period of the study. Good data on the numbers present were not obtained but it was estimated that the population in the Minnesota caves dropped about 60 per cent between 1949 and 1954.

An over-all mortality rate of about 40 per cent per year was calculated for this theoretical population (Table 2). There is a general trend towards an increased survival rate with an increase in age. A mortality rate of about 62 per cent was determined for the first year after banding, 33 per cent for the second year and 23 per cent per year for the subsequent years. The over all mortality rate of 40 per cent is the same as that given by Eisentraut (1947) but differs from his work in that it suggests that the mortality rates are age specific.

The average minimum age of the bats recovered was 2.6 years and the greatest minimum age was 9 years (Table 2). This is also the maximum age reported to date for this species (Banfield, 1950; Hitchcock, 1949; Mohr, 1952). It is probable that an occasional big brown bat may reach an age greater than this but the proportion is probably so small that it has little or no effect on the total population.

The small amount of data that has been published on young bats indicates that the sex ratio at birth is not far from 1 to 1 (Reynolds, 1942; Griffin, 1940*b*;

TABLE 2.—*Life table for big brown bats based on combined mortality and survival data*

Years after banding	Available banded population	Number reported	No. per 1,000 banded	Alive at start	Mortality rate in %
1	3871	201	51.9	84.0	61.8
2	3174	34	10.7	32.1	33.3
3	2923	9	3.1	21.4	
4	1753	0	0	18.3	
5	425	0	0	18.3	
6	425	3	7.1	18.3	22.6
7	425	1	2.4	11.2	
8	425	1	2.4	8.8	
9	312	2	6.4	6.4	
10	312	0			
		251	84.0	208.8	40.4

Cagle and Cockrum, 1943; Hitchcock, 1949). In contrast to this most of the published reports on wintering concentrations of bats in North America have shown an unbalanced sex ratio in favor of the males. These published ratios for big brown bats vary from 32 to 78.6 per cent males (Mohr, 1952; Hitchcock, 1949; Rysgaard, 1942). The 68.1 per cent males found in the populations handled falls within this range and is only slightly below that reported for most of the populations.

These data indicate a differential mortality working against the females as suggested by Griffin (1940) and Eisentraut (1947). If this is the case the sex ratio of the banded bats returned after one or more years should show a greater proportion of males than was found in the original sample. Mohr (1945) was unable to show any appreciable difference in sex ratio when he compared a relatively small sample of returns with the original banding.

In all, 245 bats of known sex were returned after one or more years with an average lapse time of 1.3 years after banding. This sample was composed of 68.2 per cent males which is not significantly different from the 68.1 per cent

TABLE 3.—*Recovery of bats by sex, Eptesicus fuscus*

Year Class	♂♂	♀♀	??	Total	% ♂♂
	No. Banded 2486	1312	73	3871	68.1
1	131	68	2	201	
2	27	7		34	
3	7	2		9	
4				0	
5				0	
6	1		2	3	
7	1			1	
8			1	1	
9		1	1	2	
Total Returns	167	78	6	251	68.2

males in the original sample. These data indicate that the mortality rate in adult bats is the same for the two sexes.

That there are differences in the habits in the two sexes of these bats is shown when one examines the sex ratios of bats found wintering in places other than the one in which they were banded. Only two of the 12 bats recovered under these conditions were females.

The possibility that the females tend to hibernate in small groups in houses and other inaccessible places is suggested by Hitchcock (1949). He found that only 7 of 17 big brown bats found hibernating in buildings to be males. Rysgaard (1942) also found that the clusters of bats were primarily males while the singles were primarily females. Hitchcock (1949) was unable to confirm this latter point. At this time the data point toward the possibility that there is a difference in the hibernating habits of the two sexes of this species and that the samples normally taken in caves in winter do not give a true picture of the sex ratios of the populations.

CONCLUSIONS

This study is based on some 3871 bats banded between 1940 and 1953. The returns from these bats indicate that this species does not travel great distances. A maximum distance of 33 miles for summer and 61 miles for winter movements were found. Most of the movements both winter and summer were within a 10 mile radius of the point of banding. A mortality rate of about 40 per cent per year was calculated with higher mortality rates being recorded for the years immediately following banding. These figures are based on a population that is declining in numbers. A sex ratio of about 68.1 per cent males was obtained and there appeared to be no differential mortality between the sexes in the adult bats. The males are more prone to move from the point of original banding than are the females.

Acknowledgment.—This study was partially supported by a Grant-in-Aid from the Sigma Xi Research Fund.

LITERATURE CITED

Banfield, A. W. F. 1948. Longevity of the big brown bat. Jour. Mamm., 29: 418.

———. 1950. A further note on the longevity of the big brown bat. Jour. Mamm., 31: 455.

Cagle, F. R. and L. Cockrum. 1943. Notes on a summer colony of *Myotis lucifugus lucifugus*. Jour. Mamm., 24: 474–492.

Eisentraut, M. 1947. Die mit Hilfe der Beringungsmethode erzielten Ergebnisse über Lebensdour und jährliche Vertustziffern bei *Myotis myotis* Borkh. Experimentia 3: 157–158.

Griffin, D. R. 1940*a*. Migrations of New England bats. Bul. Mus. Comp. Zool., 86: 217–246.

———. 1940*b*. Notes on the life histories of New England cave bats. Jour. Mamm., 21: 181–187.

———. 1945. Travels of banded cave bats. Jour. Mamm., 26: 15–23.

Hickey, J. J. 1952. Survival studies of banded birds. U. S. Dept. of Interior, Fish and Wildl. Serv., Special Sci. Rept. No. 15, pp. 1–177.

Hitchcock, H. B. 1949. Hibernation of bats in southeastern Ontario and adjacent Quebec. The Canadian Field-Nat., 63: 47–59.

MOHR, C. C. 1939. Bat tagging in Pennsylvania. Proc. Pennsylvania Acad. Sci., 13: 43–45.

———. 1945. Sex ratios of bats in Pennsylvania. Proc. Pennsylvania Acad. of Sci., 19: 65–69.

———. 1952. A survey of bat banding in North America 1932–1951. Nat. Speliological Soc. Bul. No. 14: 3–13.

REYNOLDS, K. 1942. Notes on homing and hibernation in *Eptesicus fuscus*. The Canadian Field-Nat., 55: 132.

RYSGAARD, G. N. 1942. A study of the cave bats of Minnesota with special reference to the large brown bat, *Eptesicus fuscus fuscus* (Beauvois). Amer. Midl. Nat. 28: 245–267.

Department of Entomology and Economic Zoology, University of Minnesota, St. Paul. [Paper No. 3166, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul.] *Received July 23, 1954.*

DISTRIBUTION AND STATUS OF THE WOLVERINE IN MONTANA

BY FLETCHER E. NEWBY AND PHILIP L. WRIGHT

Wolverines (*Gulo gulo*) were probably distributed throughout the mountainous areas of Montana until the western fur trade became active. If Coues (1893) was correct in his interpretation of remarks in the journals of the Lewis and Clark expedition, possibly the earliest recorded observations of the wolverine in Montana were made in 1805 near the present city of Great Falls and in the Big Hole Valley near the Idaho-Montana border. Even as late as 1927 the wolverine population of Yellowstone Park was estimated at six or eight by Skinner (1927), but from information available from trappers and fur buyers it seems likely that in most areas of Montana the wolverine was near extinction before that time. In recent years, however, wolverines have been seen and shot or trapped with increasing frequency in the northwestern portion of the state. In an effort to evaluate this apparent regrowth of population the authors investigated many reports provided by trappers, hunters and other woodsmen. All reports which were not supported by specimens were carefully evaluated and it is believed that all presented here are completely authentic.

Although the 21 capture records date back to 1932, 18 were taken since 1939. Eleven have been shot or trapped since 1950. To our knowledge, recent sight records of wolverines began only in 1944 and since then at least twenty observations have been made. The records obtained can be seen in Figure 1 and Tables 1 and 2.

Material from eight of the wolverines taken is in the Montana State University Zoological Collection. This includes: one mounted specimen, one skin, two skulls, one skeleton complete except for the maxillae and mandibles, two skulls with skins, and one leg and foot.

It is of interest to determine whether these Montana specimens should be classed with the Southern Wolverine (*Gulo gulo luteus*) or with the Northern Wolverine (*G. g. luscus*). Since Grinnell, Dixon and Linsdale (1937) indicated that *G. g. luteus* is recognizable only by possessing smaller dentition, measure-

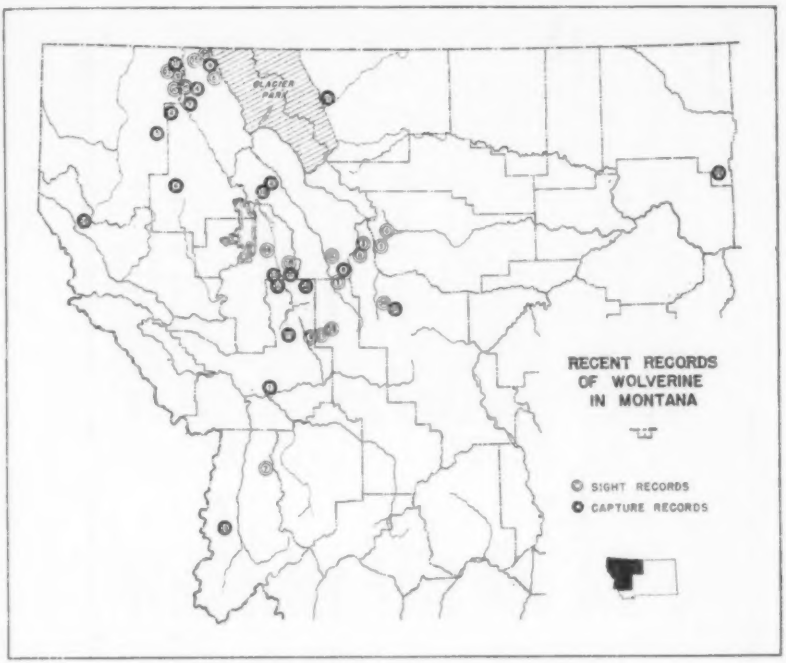


FIG. 1.—Recent records of wolverine in Montana.

ments were taken from the four skulls and compared with those presented by Grinnell, Dixon and Linsdale (1937) and also with measurements taken from a series of skulls from northern Alaska available to the junior author through the courtesy of Dr. Robert Rausch, Arctic Health Research Center, Anchorage, Alaska. Three of the Montana skulls are known to have come from males and the other is probably a male. Since Grinnell, Dixon, and Linsdale (1937) consider the tooth measurements to be critical, these data are summarized in Table 3.

The measurements of the Montana skulls in all cases but one lie within the range of the Alaskan series. Accordingly the former are regarded as belonging to the subspecies *G. g. luscus*. Parenthetically it should be pointed out that the measurements presented by Grinnell, Dixon and Linsdale (1937) of the dentition of a California male wolverine with supposed "noticeably and uniformly lighter dentition" also lie within the range of the series of Alaskan specimens. In view of this, surely the status of the subspecies *G. g. luteus* should be reinvestigated.

Lack of adequate earlier records of wolverine distribution makes accurate appraisal of the significance of recent records difficult. It is recognized that there may be a tendency for older records of observations and captures to escape notice; even so, the evidence strongly suggests an increase in population.

Although scattered individuals may have survived the intensive trapping of

TABLE 1.—*Sight records of wolverine in Montana*

No.	Date	Locality	County	Observer	Remarks
1	Mar. 1, 1944	White River Flats	Powell	Lloyd McDowell, M.F.G.D.* Horace Godfrey, U.S.F.S.**	
2	Mar. 1, 1945	Black Bear Landing Field	Flathead	Lloyd McDowell, M.F.G.D. Horace Godfrey, U.S.F.S.	
3	Aug. 27, 1947	Red Shale Creek	Lewis & Clark	Faye Couey, M.F.G.D.	2, seen by 15 people
4	1947	Teton River	Teton	U.S.F.S. Crew	
5	Aug., 1947	Headquarters Creek	Teton	Ray Gibler, U.S.F.S.	2
6	1948 or '49	Red Meadow Creek	Flathead	Ross Wilson, M.F.G.D. Lawrence Deist, M.F.G.D.	
7	Spring, 1948	Burnt Fork	Ravalli	Orville Lewis, M.S.U.***	
8	Summer, 1948	Rock Creek	Lewis & Clark	Paul Hazel, U.S.F.S.	
9	Oct., 1949	Rice Creek Ridge	Missoula	Joseph Townsend, M.F.G.D.	
10	Aug. 1, 1950	Stillwater River	Lincoln	R. T. Cloninger, U.S.F.S. J. L. Aemesegger, U.S.F.S.	4, young
11	Aug. 29, 1950	Williams Creek	Lincoln	J. L. Aemesegger, U.S.F.S.	
12	Sept. 13 or 14, 1950	Young's Creek	Powell	Wesley Woodgerd, M.F.G.D.	
13	Sept., 1951	Krinklehorn Lake	Lincoln	W. R. Ellis, U.S.F.S.	
14	June 21, 1952	Woodward Meadows	Lake	O. J. Nollar, M.F.G.D.	
15	Summer, 1952	Trail Creek	Flathead	G. M. Daugharty, U.S.F.S.	
16	August, 1952	Wood Creek	Lewis & Clark	Dan Neal, U.S.F.S.	2
17	October 18, 1952	Pyramid Pass	Powell	William McCurdy, M.S.U.	
18	May, 1953	Lion Creek	Lake	G. M. Daugharty, U.S.F.S.	
19	July 3, 1953	No. Fk. Fitzsimmons Creek	Lincoln	Wm. Maloit, M.F.G.D.	
20	Nov. 6, 1953	No. Fk. Flathead R.	Flathead	Dan Block, M.F.G.D.	

In addition, a considerable number of sight and track records have been obtained in Glacier National Park in the last fifteen years.

* Montana Fish and Game Department.

** United States Forest Service.

*** Montana State University.

TABLE 2.—*Capture records of wolverine in Montana*

No.	Date	Locality	County	Sex	Collector	Examined
1	1932	Marshall Creek	Missoula	Unknown	Robert Anderson, Polson	Report only
2	Jan., 1933 or 1934	Forks of Sunday & Advent Creeks	Flathead	Male	Tom White, Stryker	Report only
3	Winter, 1939	Pioneer Ridge	Flathead	Female	Ray Miller, Kalispell	Report only
4	Dec., 1940	Red Meadow Lake	Flathead	Female	Tom White, Stryker	Skull, *MZ**
5	Winter, about 1940	Wolk Creek-Fortine Creek Divide	Lincoln	Two—unknown	Oscar Grey, Fortine	Report only
6	Winter, about 1941	Haskill Pass	Flathead	Male	Hugh Galloway, Kila	Skin
7	Fall, 1945	Near Fish Lake	Flathead	Male	Ray Miller, Kalispell	Whole mount, *MZ*
8	Fall, about 1946	White River	Flathead	Female	H. C. Jorgenson, Polson	Skin
9	March, 1946	Teepee Creek	Flathead	Male	Louis Haverlandt, Eureka	Skin
10	Winter, 1948	Ford Creek	Lewis & Clark	Unknown	J. Hinkel, Augusta	Report only
11	Winter, 1950	Graves Creek	Lincoln	Female	W. R. Ellis, Fortine	Skin, *MZ*
12	Fall, 1951	Albino Basin	Missoula	Unknown	Big game hunter	Report only
13	Dec. 11 or 12, 1951	Teepee Ridge	Lake	Male	Glenn Clothier, Swan Lake	Report only
14	Feb. 15, 1952	Swamp Creek	Sanders	Male	Will Fox, Trout Creek	Skull, *MZ*
15	Feb. 26, 1952	Wolf Creek	Flathead	Female	Carrol Eslick, Bigfork	Whole mount
16	March, 1952	Jim Creek	Missoula	Male	John Hulett, Swan Lake	Whole mount
17	Aug. 21, 1952	So. Fk. Milk R.	Glacier	Male	Alfred Vance, Browning	Skin and Skull, *MZ*
18	Summer, 1952	Lake Como	Ravalli	Unknown	Cause of death unknown	Leg & foot, *MZ*
19	Mar. 18, 1953	Bear Paw Mts.	Hill	Male	Earl Seyler, Havre	Skin and Skull *MZ*
20	Apr. 10, 1953	Swan Valley	Lake	Female	Wm. Woodward, Missoula	Skeleton, *MZ*
21	July, 1953	Lake Elsina Area	Missoula	Two—male & female	Robert Boyce, Missoula	Report only

* Specimens now in the Montana State University Museum of Zoology.

TABLE 3.—*Tooth measurements (in millimeters) of wolverines*

		Ant.-Post. Up. canine	Ant.-Post. Up. carnas.	Trans. dia. Up. carnas.	Trans. dia. Up. molar	Max. tooth row
Northern Alaska						
Means of 18 Males from northern Alaska		11.1	21.2	12.3	14.0	53.7
Minimum		10.4	20.2	11.6	13.4	50.7
Maximum		12.2	21.9	13.3	15.0	56.3
Montana						
Red Meadow Lake	MSUZ 459	11.1	20.7	11.8	13.1	51.7
Swamp Creek	MSUZ 3845	11.0	20.5	—	14.0	56.7
South Fork Milk River	MSUZ 3901	10.8	20.4	12.0	14.0	54.0
Bear Paw Range	MSUZ 3928	11.4	20.5	11.9	13.5	51.8
California						
Yosemite National Park	MVZ 22121	10.8	20.3	11.9	13.7	51.5

early days, the distribution and chronology of the recent records do not indicate a regrowth of population due to local reproduction. It appears instead that dispersal from Canada, and later, Glacier National Park may have been responsible. Reference to Figure 1 shows that the majority of the recent records are restricted to the extensive mountain ranges along the Continental Divide in northwestern Montana. It is emphasized that there are a number of other areas of wilderness in Montana that should provide suitable habitat for wolverines. Wolverines were trapped from the Park area before establishment of Glacier National Park in 1910, but in 1918 Bailey quoted a local resident as believing them to be completely absent from the Park. Examination of National Park Service records indicated that tracks were first seen again in 1933. Since then tracks and observations have been reported from the Park almost every year. It is probable that the protected area of the Park served as a reservoir of breeding stock. Without such an area, re-establishment of the species would have been difficult, for the wolverine is completely unprotected in Montana. The establishment of closed or limited seasons on marten in later years aided in the survival of dispersing individuals by restricting the operations of trappers in wolverine habitat. Low prices for marten and Canada lynx pelts in recent years have caused an additional decline in the activities of trappers in remote areas.

Although a wolverine was taken by a trapper west of Glacier National Park in 1933 or 1934, regular reports outside the Park did not begin until 1939. In 1942, estimates of Fish and Game Department personnel placed the number of wolverines in the Whitefish Range west of the Park at four. The number of sight and kill records in that area since then indicates an increasing population. Then, after many years of apparent absence, wolverines were seen east of the Continental Divide in the Sun and Teton River drainages in 1947. Isolated reports from the Bitterroot Range in 1948 and 1952 and from the Cabinet Range in 1952 may also represent dispersing individuals.

Most remarkable of all the records is the adult male wolverine killed in the Bear Paw Mountains south of Havre, Montana in 1953. These mountains are

a small, isolated range approximately 150 air miles east of the main range of the Rocky Mountains. It seems unlikely that this small area could have concealed a wolverine population unnoticed for long, since it is an Indian reservation and is subjected to considerable trapping pressure. A report of similar nature was obtained from the trapper who took the Cabinet Mountains specimen in 1952. He reported that in the 1920's he caught a wolverine in the Sweetgrass Hills, another small, isolated mountain range about one hundred air miles east of Glacier National Park. Although this report could not be verified, the circumstances certainly parallel those of the Bear Paw record. We can only theorize that these animals reached these isolated ranges by following the broken topography and scattered timber along rivers such as the Teton, Marias and Milk which flow eastward from the main range of the Rockies. Other records that provide further evidence of the travelling ability of the wolverine have come from Washington and Idaho. Scheffer (1941) reported an adult male taken in the Okanagan Valley near Riverside, Washington, and a Boise, Idaho newspaper of March 30, 1954, carried an account of a wolverine killed by Idaho Game Department personnel near Caldwell. Both records were considered unusual for their location by local authorities and were far from areas of boreal forest.

Evidence of successful reproduction was provided by the observation of four young wolverine on the Stillwater River in 1950. Additional evidence of breeding activity may lie in four observations involving two animals each in July and August, since the breeding season in this species apparently lies in midsummer (Wright and Rausch, MS). The wolverine is reputed by naturalists to be a solitary animal and no such records of pairs were obtained at any other time of year.

It seems reasonable to conclude from the data presented that the wolverine is not at present threatened with extinction but instead may be increasing its numbers and repopulating its range in Montana. However, extensive logging operations have made rapid inroads into many areas of excellent wolverine habitat in recent attempts to control depredations of the spruce bark beetle (*Dendroctonus engelmanni*). If this situation continues our protected wilderness areas and National Parks will be the only areas remaining with suitable habitat for animals such as the wolverine, Canada lynx, marten and grizzly bear.

LITERATURE CITED

BAILEY, V. AND FLORENCE M. BAILEY. 1918. Wild animals of Glacier National Park. U. S. Government Printing Office, Washington, D. C.: 90–91.

COUES, E. 1893. History of the expedition under the command of Lewis and Clark. Francis P. Harper. N. Y., Vol. 2: 372, 486.

GRINNELL, J., J. DIXON, AND J. M. LINSDALE. 1937. Fur-bearing mammals of California: their natural history, systematic status and relations to man. Univ. Calif. Press, Berkeley, Vol. 2: 251–256.

SCHEFFER, V. B. 1941. Wolverine captured in Okanagan Co., Wn. Murrelet, 22: 37.

SKINNER, M. P. 1927. The predatory and fur-bearing animals of the Yellowstone National Park. Roosevelt Wildlife Bulletin, 4 (2): 194–195.

WRIGHT, P. L. AND R. RAUSCH. (In press) Reproduction in the wolverine (Gulo gulo).

Montana Fish and Game Department, Helena, and Montana State University, Missoula.
Received August 7, 1954.

MAMMAL OBSERVATIONS AT LOWER BACK RIVER, NORTHWEST TERRITORIES, CANADA

By H. L. Gunderson, W. J. Breckenridge, and J. A. Jarosz

The Back River drains the interior barrens of the Northwest Territories of Canada. According to Blanchet (1930) the river has its headwaters in a high plateau and flows through a sand plain basin (not in accord with conditions of our base camp). The country north of the Back River drainage is of low relief. The river takes a northerly direction for the last one-third of its course. To the east, between the river and Wager Bay, the country is known to be very rugged.

The first known exploration of the Back River, then called the Great Fish River, was by Sir George Back and his party, who left England in 1833 to search for Sir John Ross. Back's party wintered at Ft. Reliance. During the summer of 1834 they went down the Back River to its mouth and returned to Ft. Reliance where they again spent the winter, returning to England in 1835. In the appendix of Back's report (1836) there is a list of specimens collected and observed. The collecting was done by Mr. Richard King, surgeon to the expedition.

In 1855 Chief Factor James Anderson of the Hudson's Bay Company made a similar journey (Clarke, 1940*a*) hoping to find traces of the ill-fated Franklin Expedition. Both these exploring trips support Stefansson's statement (1929) that much arctic exploration has been a by-product of search parties.

So far as is known, Back and Anderson and their parties were the only white men who had visited in summer the area selected for the University of Minnesota-Wilkie Foundation expedition to the Back River. Members of the expedition were Dr. W. J. Breckenridge, Harvey L. Gunderson, John A. Jarosz, R. Spence Taylor, Robert J. Wilkie, James W. Wilkie and Dr. Lawrence Larson. The party was in the vicinity of Mount Meadowbank along the Back River from July 13 to August 6, 1953.

Our camp was located at an elevation of about 150 feet above sea level on a bay of the Back River at 66°10′ N. latitude and 96°57′ W. longitude, about 125 miles northwest of Baker Lake. The topography in the vicinity of camp was undulating with many high hills. The highest of these was Mount Meadowbank with an altitude of 570 feet. Some of the hills were composed of metamorphosed rock outcrops, others of rubble dumped by retreating glaciers, and eskers of many miles in length were not uncommon. The surface of the hills was covered with material ranging in size from gravel to desk-sized boulders, most often one or the other, rarely both.

Those valleys and depressions not filled with water, had carpets of sedge and moss-covered peaty tussocks. There were innumerable small lakes. Two factors cause poor drainage in the Barren Grounds. One is the presence of permafrost, the other is that the youth of the land has not yet allowed for the development of permanent stream and river valleys, with the exception of the large rivers. Arctic soils are generally acidic because of this poor drainage and poor aeration. Organic decay by bacterial action is extremely slow due to the low temperatures. Consequently, nitrogen and salts needed by plants are rather scarce.

The plant communities of the camp area could be fitted into two categories: the rock desert and the tundra communities of Porsild's (1951) classification. The rock desert communities were found on the rock surfaces of hills and rocky slopes. Various species of crustose lichens and a few of the black foliose lichens covered the rocks. Where some soil had accumulated, there were such plants as moss pink (*Silene acaulis*), saxifrage (*Saxifraga tricuspidata*), arctic poppy (*Papaver radicatum*), crowberry (*Empetrum nigrum*), broad-leaved willow herb (*Epilobium latifolium*), cotton grass (*Eriophorum* sp.) and other grasses and sedges.

According to Porsild (1951) the tundra community differs from the rock desert community in that the tundra community has a closed or continuous cover of vegetation. This was true of the valley and wetter places where there were such species as ground birch (*Betula glandulosa*), Labrador tea (*Ledum decumbens*), bear berry (both *Arctostaphylos alpina* and *A. rubra*), white heather (*Cassiope tetragona*), fernweeds (*Pedicularis* sp.) and grasses, sedges, lichens and mosses.

Temperature readings were taken every two hours, when time permitted, from July 15 to August 6. Minimum-maximum thermometer readings were recorded from July 20 through July 29 and on August 4, 5 and 6. Notations concerning precipitation, cloudiness and wind direction and velocity were recorded daily.

The lowest temperature recorded was 34° on July 23 and the lowest average daily temperature was 45° on July 28. The highest temperature tallied was 77° at noon on August 3. The highest daily average, 62°, was recorded on August 5. The greatest daily variation recorded was 33° (43°–76°) on August 4. Precipitation occurred on 8 days, but it was so light that it was measurable only on 4 days when 5/16, 5/16, 1/8, and 1/16 inches fell, for a total of 13/16 inch. Winds of 25–38 miles per hour (estimated from the Beaufort scale) were recorded on 2 days.

The original plan for the mammal work was to take enough traps to maintain a trap line of about 400 snap traps and 50 live traps. Because of weight and space restriction of air travel the live traps could not be taken, and several hundred snap traps were lost during field work near Churchill. Mr. Cecil Law of the Defense Research Board at Ft. Churchill loaned as many traps as he could spare. This loan made a total of 105 small snap traps, 8 rat traps, and 6 jump traps (No. 1). Some traps were left unbaited, others were baited with rolled oats, peanut butter or dehydrated apples. So few specimens were caught that bait preference data would not be worthwhile interpreting. So far as mammals were concerned, the Barren Grounds seemed aptly named.

A few specimens were lost when the plane carrying the Wilkie brothers and Lawrence Larson back to Churchill was forced down on Lake Kaminuriak.

ACCOUNTS OF SPECIES

Ursus arctos horribilis. Barren Grounds grizzly.—We did not see any evidence of grizzly bears in the camp area. Mr. A. Lunan of the Hudson's Bay Post at Baker Lake, which serves the Eskimos of the Thelon River and of the Back River to the north, said that Eskimos do occasionally bring in skins of grizzly bears. Regarding the scientific name of the grizzlies in this area, Rausch (1953) believes, "At present it seems best to use the name *Ursus arctos horribilis* for the grizzlies of northern Canada and mainland Alaska."

Mr. Lunan told of having several bearskins brought to the post that were smaller than grizzlies and smoky in appearance. Could this possibly be a glacier bear, a color phase of the black bear? Black bears, which are numerous up to tree line, are sometimes found out on the barrens.

Alopex lagopus. Arctic fox.—An arctic fox den was found about 3½ miles west of camp. The burrows occupied the greater part of a pear-shaped, gravelly knoll, which varied from three to ten feet in height. This mound, possibly the remnant of an esker, was about twenty-five yards in diameter at the large end and about 60 yards in length.

The mound was covered with a luxurious growth of vegetation, mostly grasses, of which *Calamagrostis neglecta* was most abundant. Other common grasses were *Calamagrostis inexpansa*, *Poa arctica*, *Hierochloa alpina*, and *Alopecurus alpinus*. Two other plants which were fairly common on the mound were *Taraxacum lacerum* and an arctic variety of *Equisetum arvense*. As previously mentioned, there is a definite lack of nitrogen and salts in arctic soils. The addition of fertilizers resulting from the remains of food material and excrement, and the addition of nitrates from the urea accounted for the increased vegetation of the mound.

In the center of the mound there was a bare gravel area about five feet across, where an adult would keep watch, or at times lie down. It probably served as a "watch post" from which it could observe enemies approaching, or scan the surrounding meadow for prey. Parry's ground squirrels occupied this meadow, and several times they were observed at the opposite end of the mound from the watch post. Some small burrows here were apparently those of the ground squirrels, but whether permanently or sporadically occupied could not be determined.

The mound could be approached to within 100 yards before the adult would disappear into a burrow. Only one adult, never two, were seen at a time. There were three young. We could hear the kits barking within the burrows when we were on the mound. They apparently remained within the burrow until called out by an adult. At one time we set traps at the den when no adult was present. After setting the traps we retreated to a high hill to watch. After two hours and fifteen minutes, an adult approached, went to the "watch post," sniffed the air in several directions, examined the traps, walked back and forth several times, and not until then did the kits appear on the surface.

At one time we found a freshly killed Parry's ground squirrel cached away and partly covered over, about fifty yards from the den. The ground squirrel was covered with saliva around the neck and head and had apparently been recently cached by the fox, probably when it was disturbed by us. At another time a collared lemming was found on a well-worn path leading up the side of the mound. The lemming, too, was wet with saliva and had evidently been dropped by the adult fox on finding us near the den.

The scats around the den contained a great deal of hair of Parry's ground squirrel and the skulls of lemmings. There were also remains of caribou bones. One eight-inch piece of caribou femur, lying near the watch post, was well worn with tooth marks and probably served as a "toy" for the kits. An unusual food item was a piece of skin from an arctic char (*Salvelinus subalpinus*). At higher water levels arctic char could possibly have come up the stream near the mound, but at the time we were there the fox would have had to travel at least three-quarters of a mile to get the fish. At another arctic fox den about 12 miles south of camp, ptarmigan (possibly rock ptarmigan) feathers and the foot of an immature arctic hare were found. Probably the major food item of the arctic fox at the time we were in the area was the Parry's ground squirrel.

At least 10 weathered skulls of arctic foxes were found near our camp. Most likely these were an accumulation from the previous trapping activities of Eskimos who had lived at the unoccupied site near our camp.

Two immature male arctic foxes were collected. The last one collected on August 5 weighed 4½ pounds and measured 718 mm. and was probably nearly full grown. The other, collected on July 21, weighed 3½ pounds and measured 612 mm. The color patterns matched the descriptions given by Preble (1902) for the summer pelage of the young.

There are few descriptions of the summer pelage of arctic fox. We were surprised at the

pattern of dark (seal brown to gray) head, back, base of tail dorsally and extending down the outer side of the legs contrasting with the light fawn of the sides, underparts and ventral surface of the tail. Neither Merriam (1902) nor Preble (1902) mentioned a characteristic small patch of white hairs on the dorsal side of the tail about a quarter of the way out from the base, which we found conspicuous at a distance. We do not know whether this was a character of the few individuals we saw or whether it is typical of all arctic foxes.

Canis lupus. Arctic wolf.—The tracks of an arctic wolf were seen in wet sand about a mile west of camp. Two arctic wolf skins were examined at an Eskimo camp about thirty miles from camp. Both specimens were very light, almost white. The larger of the two specimens was purchased but was lost in the plane accident.

Citellus parryi. Parry's ground squirrel.—These ground squirrels were commonly seen but were most numerous in sandy areas and along eroded banks. Again, as was the case with the fox den, the mounds and other areas of concentrated burrows supported a luxurious growth of vegetation.

At the time we arrived at the Back River the young appeared to be at least half-grown and were no longer segregated into family groups. The young and adults did not seem to mix but this might have been due to the wariness of the adults who were also more solitary, whereas the young were more often seen in small groups. Both young and adults travelled greater distances than do most of the ground squirrels of temperate regions with which we are familiar. One young travelled from a burrow mound to a bank about 200 yards distant. An adult travelled over 400 yards in a straight line.

The ground squirrels fed on seeds of grasses, sedges, willows, and, in one instance, bear berry. Grass seeds were procured in several ways. The animal took one species of grass (*Poa arctica*) by the stalk in the front paws and ran the stalk through its mouth, stripping off the seeds. Other grasses, *Hierochloa alpina* and *Calamagrostis inexpansa*, were eaten seed by seed. Leaves of arctic avens (*Dryas integrifolia*) also were taken.

One immature ground squirrel, taking a nap in the sun, curled up in an upright position, sitting on his hind feet with his head and front legs tucked under himself. This is the posture so often taken by other species of ground squirrels during hibernation.

The ground squirrels collected the last week of July were extremely fat, particularly a young one. Allee, *et al.* (1949) wrote on page 105, "Where the soil is permanently frozen beneath the level reached by summer thaws, hibernation of burrowing mammals cannot take place, and hence is absent in polar regions." At first glance this may seem logical, yet Parry's ground squirrels do hibernate. While many references have been made to hibernating Parry's ground squirrels in the past literature starting as far back as Richardson, actual research on the physiology has been done only recently. The two most recent articles are Wilber and Musacchia (1951) and Musacchia and Wilber (1952), working on hibernating ground squirrels at Point Barrow, Alaska.

Mayer (1953) wrote, "Even in the arctic, however, a relatively low permafrost table exists in certain areas correlated with good drainage, and within these restricted regions ground squirrels have a suitable habitat. Thus, though the coastal plain is flat. . .the squirrels may locate their burrows in the ridges and river sandbanks, hillocks and other raised areas with a sandy soil, sandy loam soil or sandy clay soil." Gavin (1945) wrote concerning the Parry's ground squirrel, "Abundant in the sandy country at the mouths of rivers and along the coast where burrowing is easy." Hanson (unpublished ms.) wrote, "In instances where their burrows lay close to the river banks, [in early spring] they had to tunnel up through five to six feet of snow before reaching the surface." Even with the light snowfalls in the Barren Grounds, deep drifts accumulate below protecting banks, and it is probable that the burrowing along such banks, together with the protection of the snowdrifts, makes hibernation possible.

Lemmus trimucronatus. Brown lemming.—Brown lemmings either were not very abundant or did not get into the traps readily. Twenty six were caught in 1898 trap nights to give a trap-night figure of .014. Seven adults and 18 immatures were caught. All adult specimens were lost in the plane accident. The first young were caught on July 23 (trapping started July 16). During the first part of the season, no brown lemmings were caught in fifty traps

set in a boggy area of sphagnum hummocks and willows, but they began appearing in these same traps on July 24. This seemed to indicate a movement into an area which earlier had most likely been too wet.

Dicrostonyx groenlandicus. Collared lemming.—Only four collared lemming were caught in 1898 trap nights giving a figure of .002. There were two adults and two young. The two adults weighed 49.6 and 57.1 grams. Another specimen was found at the arctic fox den. The collared lemming were taken in the higher and drier communities, called "rock desert communities" by Porsild (1951). None were taken in the boggy areas. It would appear that the two genera of lemming are ecologically separated, the collared lemming found in drier areas and the brown lemming in wetter areas.

The populations of the collared lemming were obviously very low. Shelford (1943) estimated the magnitude of population fluctuations (at Churchill, Manitoba) as from 6 to 7 individuals per 250 acres to 4,000 individuals per 250 acres.

Lepus arcticus. Arctic hare.—Only four arctic hares were seen by the entire party at the Back River. An adult male, in gray pelage, was collected and weighed 6½ pounds. Mr. A. Lunan of Baker Lake said that arctic hares have been very scarce the last few years.

Rangifer arcticus. Barren Ground caribou.—No caribou were seen near our campsite, but a few tracks considered to be fresh were observed. In the saddle of a hill several hundred yards west of camp were tent rings and rock mounds of an old Eskimo campsite. Here there were many caribou bones. All of the long bones were broken, showing the Eskimos had used them for food. At the Eskimo camp about thirty miles down river, there were many caribou bones and pieces of skin lying on the ground and three stone caches which apparently contained caribou. By one partly opened cache there were many pieces of caribou skin and bones. One Eskimo family lived in a tent made of caribou skins.

Caribou bones were found at some rough-legged hawk nests and also at the arctic fox den. There was a recent caribou crossing near Sinclair Falls where a thick mat of caribou hair lined the south side of the Back River for a distance of nearly a hundred yards. River level records indicated the herd had crossed 3 to 4 weeks before or early in July. According to Banfield's (1951) maps, there would not be many caribou in the vicinity of our camp at any season.

Ovibos moschatus. Muskoxen.—The only evidence of muskoxen was the weathered part of a skull found near the campsite. George Back (1936), the first white man to explore the river, observed in 1834, "Both sides [of the river] were hemmed in by mountains . . . the green shelving slopes dotted with herds of musk oxen." At noon of the same day, "A glimpse of the sun . . . gave the latitude of 66° 6′ 24″ N; nearly abreast of a picturesque and commanding mountain . . . where cattle were feeding . . . and I called the hill Mount Meadowbank. . . ." The term "cattle" without much doubt refers to muskoxen. Anderson followed the Back River in 1855 and wrote (from Clarke, 1940*a*), "One third this day nearly lost by our mistaking a channel of the river . . . [probably the Meadowbank]. Two large bands of musk oxen were seen just before encamping." From these reports muskoxen must have been fairly numerous in the area in earlier times. But they evidently suffered the fate of a fad for muskoxen robes that followed the disappearance of buffalo. The hunting of muskoxen for the robes probably reached its height somewhere about 1913. At any rate, they have disappeared from the area and Clarke (1940*b*) wrote, "None of the Back River or Meadowbank River Eskimos have reported any muskoxen for a number of years."

LITERATURE CITED

ALLEE, W. C. *et al.* 1949. Principles of animal ecology. W. B. Saunders, Philadelphia. 837 p.

BACK, G. 1836. Narrative of the arctic land expedition to the mouth of the Great Fish River, and along the shores of the Arctic Ocean in the years 1833, 1834, and 1835. E. C. Carey and H. Hart, Philadelphia.

BANFIELD, A. W. F. 1951. The Barren-ground caribou. Dept. Resources and Development. Ottawa, Canada.

BLANCHET, T. H. 1930. Keewatin and northeastern Mackenzie. Dept. Interior, Ottawa, Canada.

CLARKE, C. H. D. 1940*a*. Chief factor James Anderson's Back River Journal of 1855. Canadian Field Nat. 54: 134 and 55: 9, 1941.

——— 1940*b*. A biological investigation of the Thelon Game Sanctuary. Canada. Nat. Mus. Bul. No. 96, Biol. Ser. No. 25.

GAVIN, A. 1945. Notes on mammals observed in the Perry River District, Queen Maud Sea. Jour. Mamm., 26: 226–230.

HANSON, H. C. Unpublished report of the Perry River Expedition.

KING, R. 1836. Appendix 6, pp. 590–594 of Narrative of a journey to the shores of the Arctic Ocean in 1833, 1834, and 1835 under the command of Captain Back. R. N. London, R. Bentley.

MAYER, W. J. 1953. Preliminary study of the barren ground squirrel, *Citellus parryi barrowensis*. Jour. Mamm., 34: 334–345.

MERRIAM, C. H. 1902. Four new arctic foxes. Proc. Biol. Soc. Washington, 15: 170–174.

MUSACCHIA, X. J. AND C. G. WILBER. 1952. Studies on the biochemistry of the arctic ground squirrel. Jour. Mamm., 33: 356–362.

PREBLE, E. A. 1902. A biological investigation of the Hudson Bay region. North Amer. Fauna No. 22.

PORSILD, A. E. 1951. Plant life in the arctic. Nat. Mus. Canada. Ottawa, Canada. 27 p.

RAUSCH, R. 1953. On the status of some arctic mammals. Arctic, 6: 91–148.

SHELFORD, V. E. 1943. The abundance of the collared lemming (*Dicrostonyx groenlandicus* (Tr.) var. *richardsoni* Mer) in the Churchill area, 1929 to 1940. Ecology, 24: 472–484.

WILBER, C. G. AND X. J. MUSACCHIA. 1950. Fat metabolism in the arctic ground squirrel. Jour. Mamm., 31: 304–309.

Minnesota Museum of Natural History, University of Minnesota, Minneapolis. Received June 10, 1954.

RATS OF ARNO ATOLL, MARSHALL ISLANDS

BY JOE T. MARSHALL, JR.

The following information on rats was recorded during the summer of 1950 as part of a study I made on land vertebrates of Arno Atoll, Marshall Islands while a member of a party sent by the Pacific Science Board of the National Research Council, supported by the Office of Naval Research, to study the ecology of a typical low coral atoll. Most of the observations are of undisturbed rats; others were flushed from hiding places, and a few were collected: 17 Polynesian rats, *Rattus exulans* (of which eight are preserved at the U. S. National Museum), and two black rats, *R. rattus* (both at the museum). I am grateful to David H. Johnson of that museum for confirming the identifications of these specimens, to Lee Douglas for examining the tapeworms, and to Lois Taylor for care of the preserved helminths and caecal protozoa. The Arnoese people are very hospitable, and they extended numerous courtesies as well as technical assistance—such as the identification of plants by Mr. Konto. These people are notable for their extended knowledge of, and intelligent interest in natural history. *Kijirik* is their word for rat.

Although the common name "black rat" is used here for the species *R. rattus*, it should be understood that, in the Pacific at least, the several named color phases may be found in the same litter.

Arno's five square miles, all under 12 feet high, are disposed in numerous small

islets, many of them less than 100 yards wide. A forest of coconut palms, enriched by large breadfruit trees in the interiors of wide islands, dominates most of this area; ocean shores support thickets of *Scaevola frutescens*. The density of the forest undergrowth depends upon the amount of copra harvesting—desultory at best—by the workers responsible for each particular strip of vegetation. Thus a grassy park, in which the undergrowth and dead fronds have been burned and whose coconut husks are neatly piled, may adjoin an unattended jungle of vines, bushes, and trees mingled with the palms. Much of the parkland is near the three towns on the principal large islands; the other islets either support a few houses or are uninhabited, but portions of the most remote may be harvested and cleaned up.

The land vertebrates with which the two rat species share the atoll are (in addition to the Arnoese themselves) the dog, cat, pig, reef heron, chicken, Micronesian pigeon, New Zealand cuckoo (present during its non-breeding season), four species of nocturnal geckos, and six species of diurnal skinks. The conclusions reached by my study of the interrelations of these vertebrates are (1) that the black rat and domestic animals are entirely dependent upon man, being limited in their distribution to within about 200 yards of occupied houses, (2) that man and the remainder of these animals are independent of each other, and (3) that no species in this little society is a principal or regular item in the diet of any of its fellows.

Rattus exulans.—The Polynesian rat is a dainty nimble species, handsome in its somewhat rufous coat. It abounds throughout the areas dominated by the coconut palm. I did not see it in thatched or lumber houses in which I stayed, probably because of the numerous cats. In only two places was an effort (tearing up logs and stumps) to reveal the rat unsuccessful: the south end of Chittakinmatoroen Islet, where the vegetation is very dense and consists of only two small groves of palms surrounded by dense brush over rocks; and the north end of Autore (the next islet south) also with dense mixed growth on low ground. But rats swarmed over the opposite end of Autore, where coconuts had been harvested and the undergrowth cleared. The next islet to the south is the smallest I found inhabited by rats (4½ acres), and though it had very dense wild vegetation, two rats were seen in its dark interior during a short visit. This merely suggests irregularity in distribution, which is a more striking feature of some of the other vertebrates on Arno.

Despite considerable night observing with a head flashlight, I noticed more rats abroad on sunny days than at night. But the many flushed by day from the confines of logs, stumps, and coconut piles suggest a period of relative inactivity at that time. Typical activities of undisturbed rats seen in the open are: by day, bouncing along or across trails and along logs, poking around edges of coconut piles, weaving rapidly among ferns and vines on rocky ground, sitting or running in the base of pandanus trees; and by night, running in and out of a rock wall, sitting quietly in a cup of coconut cloth high on a palm trunk, and eating coconut flowers while climbing acrobatically up the flower stalk. The rats are no more numerous at night, but are likely to be shined in palms at a place where they are active in daytime. For instance, during an afternoon at Rakaaru Islet, a female prowled around a coconut pile in a harvested grove, then an adult male ambled along, crossed the trail, and dashed into the same pile when he saw me. I scared both rats out and they ran among the rocks to other piles. Fifty yards farther another crosed the trail. From about 8 to 10 PM at the same place and date I saw one dash down a tall leaning coconut palm from the crown foliage to the vines at the base; another for ½ hour walked along fronds in the crown of a low palm where it inspected a young fruiting stalk. I found no Polynesian rats in the tops

of palms in daytime, nor were nests found there. When flushed by day they run under boulders, logs, or piles of fronds and coconuts, rather than climb a palm. One however was smoked out of a pandanus skirt (the fringe of dead leaves surrounding the aerial roots at the base of this small tree) and it ran up this tree and along a palm frond to the top of an adjacent pandanus. The most seen by day was 7–8 prowling among coconut piles on the small islet of East Tagelib, at 1 to 3 PM on a sunny day. On Ine Island I tried to find all the rats (and other vertebrates) on a strip of vegetation 43 yards wide selected at a narrow part 54 yards between ocean and lagoon shores, where it was possible to expose every potential hiding place near the ground. These were: numerous pandanus skirts, only one large pile of husks, two big logs, and eight large palm stumps. There were seven rats and four nests revealed in this search. Three immatures were trapped at night (one at the base of a flowering palm in which it had been feeding that evening), two adults were flushed from different palm stumps, and two more adults were scared from beneath the pile of coconut husks. Two nests were in stumps, and the other two were together at the bottom of the husk pile. At this rate of abundance in about a half acre, there could be 47,000 rats on the atoll.

The punky interiors of palm stumps make fine lodgings for Polynesian rats, protected as they are by the very hard outer shell of the tree, which often provides no opening at the base, but only at the top. The rats' tunnels circle the interior at the base and run close to the shell to various chambers and nests. Twelve nests were found. Each is a ball 5–6 inches in diameter of shredded dead leaves (with or without coconut cloth) taken from the nearest handy supply of either *Polypodium scolopendria* or *Pandanus tectorius*. One old nest was open on top. Two were within pandanus skirts, but most were in piles, logs, and stumps. Two in a coconut pile were actually enclosed within the split halves of their respective husks. Of seven adult (with guard hairs) females examined, two had embryos. On a sunny afternoon I found a female with two babies on leaf litter on the overgrown forest floor. Apparently she had been moving them. They had closed eyes but were completely covered with luxuriant tawny and ruddy pelage, and had several large mites apiece. They were 40 mm. in body length. They moved downward and under things, such as leaves, as much as possible. I left them under the leaves and waited for the mother to return, which she did in ten minutes carrying off one offspring, and then the other seven minutes later.

Fresh ripe coconut meat from fallen nuts seems to be the favorite food of this rat. Some of the specimens were taken by Arnoese who enticed the rats from coconut piles by breaking open a nut and placing it beside the pile. Within a minute or so the rats came out and began to eat, only to be clubbed on the head (the reason why all were not saved as specimens). A rat, watched at night, was eating the coconut blossoms. Its stomach contents, compared with material from the flowers, showed identical cells under the compound microscope. Most of the blossoms had been eaten upon another low palm that I inspected the morning after trapping a rat that had been climbing in these flowers. The 11 stomachs examined contained vegetable material (without a trace of invertebrates), some green and some yellow (coconut flowers), some white (coconut meat), and some brown. In several stomachs two such materials were segregated at opposite ends. Some rats gather and eat the seeds of a vine, *Triumfetta procumbens*, shown by a large accumulation of the shells in and beneath an old nest in pandanus. I found no sign of intact coconuts being opened by these rats. Whether or not they *could* chew open a coconut, they do not have to because of the great supply of those already sprouted or broken. Robert Hiatt proved that land crabs are responsible for the nuts found cracked open after the husk is carefully shredded away. On Arno neither this crab nor the Polynesian rat eats green nuts either on the tree or recently fallen.

No blood protozoans were found in Polynesian rats nor in any other vertebrates on the atoll. This is related to the rarity or absence of many kinds of bloodsucking arthropods. Neither I nor the entomologists with the party, Ira LaRivers and Robert Usinger, found any fleas or biting bugs on the rats or in their nests. However, all the Polynesian rats had lice and mites, identified at the Communicable Disease Center, U. S. Public Health Service as *Hoplopleura oenomydis*, *Laelaps nuttallii*, and *L. echidninus*. Of five rat caeca from which

protozoan smears were fixed, all swarmed with the usual assemblage of flagellates. Of 12 stomachs, nematodes (other than tiny ones possibly introduced with the food) were seen in three: one had a large worm in the lumen; another a single long whipworm threaded through the mucosa; the third had several such worms threaded in and out of the lining. Another rat had ascarid eggs in its rectum, but I did not find the adult worm. A search in the intestines of ten Polynesian rats revealed 1, 2, 2, 3, 7, "many," and "many" tapeworms respectively in seven of them. According to Lee Douglas these worms resemble in many respects *Hymenolepis diminuta*; they lack hooks on the rostellum. He stated that they could possibly be transferred to man via grain-eating insects (which are numerous at Arno) as intermediate hosts. However I found no tapeworms in a stool survey of 100 Arnoese at Ine Village, nor did the ova show up in all these samples examined after salt flotation (which would have revealed eggs of *Hymenolepis*).

The only enemies of *Rattus exulans* on Arno are cats and humans. One robust dog at Ine was interested in rats but proved to be all bark and no bite. A cat brought two rats one day to its young under our house, but only rarely did I see other cats on the lookout for rats, and most ate coconut meat and garbage with the rest of the domestic animals. The people pay little attention to this rat, but knowing my interests they demonstrated the clubbing technique, and the boys tore open fallen logs to find nests.

Rattus rattus.—I found the black rat only at Ine Village, but it was reported also from two islets near the seaport on the north side of the atoll. Only in these three spots are green coconuts eaten by rats, and the Arnoese stated that large rats and opened coconuts had been found there only since the period of Japanese control of the atoll. I saw four or five in a grove of palms on the outskirts of Ine Village, on the ocean side. Here were dozens of fresh coconuts that had been eaten, some still in place on the trees, others strewn on the ground beneath. Each nut had on its side a circular opening 1½ inches in diameter, gnawed by the rat, through which the animal had crawled to eat out the entire pulp within. Two rats were shot at night from these trees: one is dark gray; the other is brown. The gray rat held a piece of hard wood in its teeth. All were very wild, and would retire to concealment higher in the palm foliage after being flushed from lower portions of the crown. Generally they were discovered by their gnawing and rustling sounds in these trees. (At this same spot one rat, probably this species, scampered across the trail at 4 PM.) The boys found two nests in a palm log near these trees. I assigned the nests to this species only by the size of the young, for the nests and their placement were exactly like those of *exulans* (except that they had no fine material). Possibly they had been appropriated from the smaller species. The six young in one nest were pink, 67 mm. in total length, and had no hair. Three in the second nest, six inches below the first, measured 94 mm.; their eyes were not open, their hair, black.

Black rats were reputed to damage stored copra at the village. The species was evidently just gaining a foot-hold on the atoll in 1950, and was in such small numbers that it could possibly have been eradicated. However, the Ine grove was on a boulder rampart within which the rats could hide if driven from the trees and logs. No *exulans* were found in these particular trees infested with *rattus*, but they and their nests occurred around the edge of the grove.

Examination of two specimens immediately after shooting revealed no ectoparasites nor blood protozoans. One, examined internally, harbored stomach nematodes but no tapeworms. In its caecum were the usual flagellates. Its stomach contained whitish vegetable material—doubtless coconut meat—and much liquid. We can at least admire the black rat's taste, for it prefers the green nut at its most delectable stage: with sweet milk and gelatinous pulp.

Conclusions.—Since copra is not intensively harvested on Arno, the minor depredations of the abundant Polynesian rat upon palm blossoms and probably also upon the stored or drying copra are insignificant in view of the great surplus of nuts allowed to sprout. The rare black rat, should it increase, would menace the crop and stores. Compared with Baker's findings on Guam (Ecol. Mono., 16: 393–408, 1946) the Arno *Rattus exulans* is more abundant

than the Guam population of the species, from which it differs further by frequenting tops of coconut palms and by not regularly eating invertebrates. The two populations are similar in their somewhat irregular distribution and marked diurnal activity.

Department of Zoology, University of Arizona, Tucson. Received August 28, 1954.

RECORDS OF *KOGIA BREVICEPS* FROM TEXAS, WITH REMARKS ON MOVEMENTS AND DISTRIBUTION

By Gordon Gunter, Carl L. Hubbs, and M. Allan Beal

Kogia breviceps (Blainville), the pygmy sperm whale, has been recorded repeatedly from the Atlantic Coast of North America (Hobbs, 1885; True, 1885; Allen, 1941, and papers cited therein; Ulmer, 1941; Enders, 1942; Brimley, 1946; Moore, 1953), but to date the only published report from the Gulf of Mexico is that of Moore (1953: 129), based on an adult that washed ashore in November, 1949, on St. Petersburg Beach, Pinellas County, Florida, and there gave birth to a calf.

First specimen from Texas.—Almost a year earlier, on December 27, 1948, another adult female (Pl. I, Upper and Middle) was stranded near the north end of Mustang Island, Nueces County, Texas, a mile south of the Aransas Pass jetties. It was examined while fresh (with blood draining from its mouth) by staff members of the Institute of Marine Science, in the absence of the first author. Photographs were taken and the head was buried on the Institute grounds, but these circumstances were not reported, because the specimen was thought to be a blackfish. The photographs were later shown to Raymond M. Gilmore, who saw that they represented the rare pygmy sperm whale, and to Hubbs, after the second specimen had come to light in Texas. Information on the buried head enabled Gunter to disinter the skull (Pl. II), minus the teeth and the lower jaw.

Certain differences seem to be indicated when the proportional measurements of the Mustang Island specimen (Table 1) are compared (Table 2) with those of Hubbs (1951: 507), for a California specimen, and of Enders (1942, Fig. 2) for a New Jersey specimen. Not many measurements are similar, because standardized criteria have not yet been developed, but seven measurements were the same or can be estimated with reasonable accuracy. The proportional width of the flukes was much the same in the California and New Jersey whales, and much less in the Texas specimen. However, it seems that the Texas carcass was twisted and that the flukes were not completely spread when measured. The flipper in the Texas animal (a female) seems to have been considerably larger, proportionally, than in the other two (both males), and since this indicated difference appears to be borne out by the photographs, the difference is probably real, but whether sexual or not remains to be seen. The length of the dorsal fin and its vertical height were much the smallest in the New Jersey specimen and this indication is apparently confirmed by a comparison of the three photographs and of Enders'

PLATE 1

UPPER AND MIDDLE: Pygmy sperm whale stranded at Mustang Island, Texas, December 27, 1948. Photographs by David Kramer.

LOWER: Pygmy sperm whale stranded at Padre Island, Texas, February 7, 1954. Photograph by M. Allan Beal.

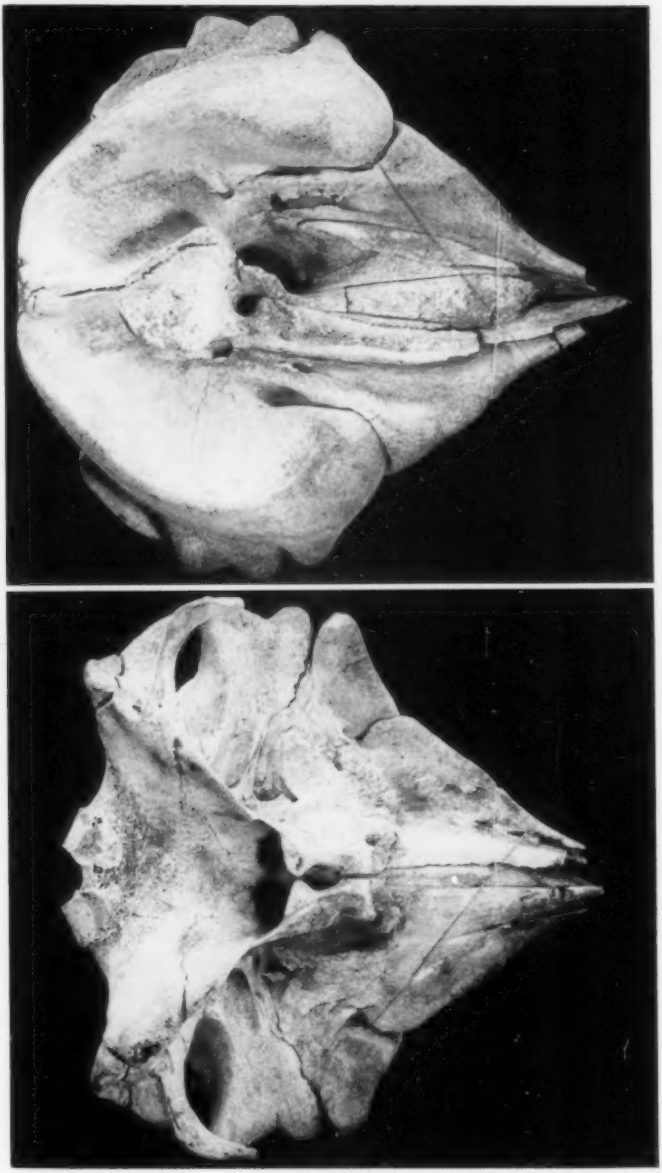


PLATE II

Skull of pygmy sperm whale stranded at Mustang Island, Texas, December 27, 1948. Dorsal view above, ventral below. Photographs by Jack Blackwell.

TABLE 1.—*Measurements of the Mustang Island specimen of Kogia breviceps*

Measurements of the carcass, by Joel W. Hedgpeth, December 28, 1948		
	Inches	Thousandths
Total length, to notch in flukes	108	1,000
Width of flukes	20	185
Length of left flipper	19–20	176–185
Dorsal fin height	5	46
Dorsal fin length	16	148
Snout tip to rear of dorsal base	75	694
Snout tip to blowhole	14	130
Snout tip to eye	16	148
Notch in flukes to rear of dorsal base	36	333
Notch in flukes to flipper base	78	722
Body depth at base of dorsal	25	231
Greatest body depth*	28	259
Measurements of the skull, by Gordon Gunter, July, 1954		
	mm.	Thousandths
Condylobasal length	443	1,000
Zygomatic width	395	892
Supraorbital width	406	916
Rostrum length	221	499
Braincase height	181	409
Braincase length	133	300 –

* About two-thirds of distance from tip to snout to posterior end of dorsal fin.

TABLE 2.—*Comparative measurements* of California, Texas, and New Jersey specimens of Kogia breviceps*

	California (male)	Texas (female)	New Jersey (male)
Flipper length	134	176	137
Dorsal fin height	66	46	31
Dorsal fin length	147	148	(60)
Snout to front of dorsal	499	(600)	516
Rear of dorsal base to fluke notch	(418)	333	436
Snout to blowhole	116	130	107
Snout to eye	156	148	110
Fluke width	242	185**	248

* The measurements are expressed in thousandths of length from tip of snout to notch between flukes of each animal. Estimates are in parentheses.

** Fluke probably not fully spread.

diagrammatic drawing of his specimen. The length of this fin was much the same in the California and Texas specimens (male and female, respectively).

The most unexpected and significant differences seem to be the measurements of snout to eye, snout to blowhole, and snout to dorsal fin. The last measurement is checked by the measurement from the fluke notch to the posterior insertion of the dorsal. These measurements and a comparison of the photographs indicate, with little doubt, that the dorsal fin of the Texas specimen was placed considerably farther back than on the other two. The blowhole of the Texas

specimen seems to have been more posteriorly placed than in the other two. The eye was considerably posterior to the blowhole in both the Texas and California animals, but Enders' diagram and measurements indicate that the eye of the New Jersey whale was only a little behind a vertical line through the blowhole. These seem not to be sexual differences, for the Texas specimen was a female and the other two were males.

Thus it appears that the body proportions of the pygmy sperm whale adults may vary considerably. The flipper may be much larger in some than in others. The dorsal fin may vary considerably in size and it may be placed much more posteriorly in some than in others. The eye may be almost vertically in line with the blowhole or considerably behind it.

None of the photographs of the Texas specimens shows the bracket-like mark figured and described by Hubbs as extending in the California example from near the ear to a point in front of the flipper, but such markings in cetaceans fade rapidly on death, particularly in specimens that have been rolled in the surf and then exposed to the sun. The information from Charles L. Camp, reported by Hubbs, shows that the mark is developed on at least some Atlantic specimens. Yamada (1954) has shown that a similar mark, with variations, occurs on Japanese specimens.

Second specimen from Texas.—The second specimen (Pl. I, Lower) to be recorded from Texas was observed and photographed by Beal on the Gulf beach of Padre Island, about 20 miles south of the latitude of Corpus Christi, on February 7, 1954, while a "norther" was blowing. No measurements were made and no parts were preserved, for the rarity of the find was not then appreciated.

Though the length of the specimen was estimated as only about nine feet, the animal appeared to be old, for its teeth were worn down to broadly rounded pegs, contrasting sharply with the needle-like structures commonly seen in this species (as shown by Hubbs, 1951, Pl. 3). The worn teeth dramatized the small size attained by this whale.

Obviously there is much variation in the size and probably in the age at which odontocetes wear their teeth down to rounded pegs. Among 33 specimens of the bottlenose dolphin, *Tursiops truncatus* (Montague), Gunter (1942: 270) noted one old female, 8.5 feet long, with much worn teeth, although the species reaches a length of 12 feet. A very similar observation has been made by Schevill and Lawrence (1953: 152). Blunt-toothed adults of *Tursiops gilli* Dall, of moderate length, have been seen by Hubbs. Similar though hardly such extreme age variation has been observed in the teeth of sperm whales, *Physeter catodon* Linnaeus; for example, by Hubbs, at the Field's Landing whaling station in California.

Movements and distribution.—The fact that both Texas specimens were taken in the winter prompts a consideration of the seasonal occurrence of pygmy sperm whales in the western North Atlantic. When the 31 available dated records are tallied (Table 3) there is to be noted a complete lack of records for the months of June, July, and August, and only two records for May (May 7 and 19). Since in these months the beaches are commonly frequented, it seems highly probable that the major population of the species in the western North Atlantic is then centered somewhere outside or beyond the inshore waters of the Atlantic Coast

TABLE 3.—*Records of the pygmy sperm whale along the western coast of the North Atlantic Ocean, arranged by six-degree bands of latitude*

Latitude	Month											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
26°–32°	1	1		1					3*		2	1
32°–38°		2		3**	2				1		1	2†
38°–44°	1	2	2	2						3‡	1	
Totals	**2**	**5**	**2**	**6**	**2**				**4**	**3**	**4**	**3**

Summary	January to May	June to August	September to December
26°–32°	3	0	6
32°–38°	7	0	4
38°–44°	7	0	4

* Including a calf with one of the two adults.

** Two of these were suspected of being a cow and an accompanying yearling.

† One of these specimens was reported by Allen (1941: 20) to have been stranded in January, but the original accounts of this specimen, by True (1885) and by Hobbs (1885), indicate the month as December.

‡ Two of these were suspected of being a mated pair.

from 26° to 44° N. Lat. There is at least a suggestion of a northward movement between fall and spring. It is quite possible that the pygmy sperm whale, like some of the larger cetaceans, moves rather far toward the poles, in the summer, to feed on the rich pelagic food supply of those regions, returning to warmer waters to breed.

Table 3 includes four hitherto unpublished records from South Carolina, supplied by the Charleston Museum, as follows: (1) male 10 feet, 1.5 inches long, stranded on Pawley's Island, Georgetown County, November 15, 1929 (No. 29.264); (2) male 6.5 feet long, with teeth not yet out of gums, reported harried and driven ashore by porpoises, on Isle of Palms, Charleston County, February 3, 1931 (No. 31.27); (3) male 10.5 feet long, stranded on Sullivan's Island, Charleston County, September 12, 1934 (No. 34.289); (4) adult specimen stranded on Seabrook's Beach, Charleston County, found in badly decomposed condition May 19, 1953, and photographed.

The seasonal distribution of the pygmy sperm whale is somewhat different from that of its large cousin, *Physeter catodon* Linnaeus. The whaling records compiled by Townsend (1935) show that the sperm whale was captured in the Caribbean Sea from February to May, in the Gulf of Mexico from March to July, and off the Atlantic Coast of the United States predominantly from April to November. These data indicate a northward drift from spring to fall. In the winter, it is thought, most of the sperm whales moved southward beyond the equator.

The relative frequency of records from temperate eastern North America and the lack of any from the western Atlantic south of the Gulf of Mexico might be taken as an indication that the pygmy sperm whale is one of the numerous tribe

(Hubbs, 1952) of more or less antitropical organisms. On the other hand, the southward decline in the number of naturalists may explain the lack of southerly records in the western Atlantic. Hirasaka (1937: 138) listed six specimens from tropical Pacific waters. Tropical Atlantic specimens are to be expected.

A curious anomaly concerning the distribution of the pygmy sperm whale seems to be coming to light. The distributional map of Hirasaka (1937) shows that 23 strandings are recorded for the western Atlantic and western Pacific and only eight from the eastern shores of these oceans. Later records (in papers cited in the introduction) have increased this disporportion. The complete lack of records from Great Britain, where strandings of cetaceans are better recorded than elsewhere, is not very significant with regard to total distribution, for there are a few records from France and Holland, but the paucity of records from northern Europe is probably significant, especially when considered in connection with the scarcity of records from western North America.

For several reasons, however, we must be guarded in our conclusions regarding the distribution of the pygmy sperm whale. The records are still too few for statistical reliability. Many strandings go unreported, or the specimens are mistaken for more common species (the two seen on the Gulf coast in 1948 and 1949 were thought to be blackfish, until brought to the attention of a cetologist). The preponderance of winter records may be due to strandings by storms, which are commonest at that season. The paucity of reports from tropical waters may be attributable, in part at least, to the limited number of marine biologists in those regions. We venture the distributional discussion, however, in the hope of encouraging the accumulation of more data on this interesting little whale and of stimulating further thought on its distribution and ecology.

In connection with the distributional analysis it should not be forgotten that some authors have recognized more than one species of *Kogia*, which, if they exist, may have different ranges. On the basis of newly acquired Japanese specimens, Yamada (1954) has considered the problem, without coming to a definite conclusion.

Acknowledgments.—We are grateful to several colleagues. David Kramer made available photographs of the first Texas specimen. Joel W. Hedgpeth provided measurements of this specimen and other information regarding it. Joseph Curtis Moore suggested the tabular treatment of the western North Atlantic records and otherwise commented helpfully on an early draft of this paper. Raymond M. Gilmore, who first identified the photographs of the Mustang Island specimen, has kindly withdrawn in our favor his plan to publish the record. E. Milby Burton and Albert Schwartz kindly made available records of specimens from South Carolina.

LITERATURE CITED

Allen, G. M. 1941. Pygmy sperm whale in the Atlantic. Zool. Ser. Field Mus. Nat. Hist., 27 (publ. 511): 17–36, figs. 1–4.

Brimley, H. H. 1946. *Kogia breviceps* and *Mesoplodon mirum* in the vicinity of Oregon Inlet, North Carolina. Jour. Mamm., 26: 434.

Enders, R. K. 1942. Notes on a stranded pigmy sperm whale (Kogia breviceps). Not. Nat., Acad. Nat. Sci. Phila., 111: 1–6, figs. 1–4.

Gunter, G. 1942. Contributions to the natural history of the bottlenose dolphin, *Tursi-*

ops truncatus (Montague), on the Texas coast, with particular reference to food habits. Jour. Mamm., 23: 267–276.

HIRASAKA, KYÔSUKE. 1937. On the pygmy sperm-whale, *Kogia breviceps* (Blainville). Mem. Fac. Sci. and Agric. Taihoku Imp. Univ., 14 (Zool., no. 7): 117–142, map 1, pls. 1–5.

HOBBS, J. R. 1885. Stranding of a pigmy sperm whale. Bul. U. S. Fish Comm., 5: 450. (Reference not included by Allen, 1941)

HUBBS, C. L. 1951. Eastern Pacific records and general distribution of the pygmy sperm whale. Jour. Mamm., 32: 403–410, pls. 1–3.

———. 1952. Antitropical distribution of fishes and other organisms. Proc. 7th Pac. Sci. Congr., 3: 324–329.

MOORE, J. C. 1953. Distribution of marine mammals to Florida waters. Amer. Midl. Nat., 49: 117–158, figs. 1–19.

SCHEVILL, W. E., AND BARBARA LAWRENCE. 1953. Auditory response of a bottlenose porpoise, Tursiops truncatus, to frequencies above 100 KC. Jour. Exp. Zool., 124: 147–165, figs. 1–2.

TOWNSEND, C. H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica, 19: 1–50, figs. 1–2, pls. 1–4.

TRUE, F. W. 1885. Notice of the capture of a male pigmy sperm whale, Kogia breviceps, at Kitty Hawk, North Carolina. Bul. U. S. Fish Comm., 5: 132–133. (Reference not included by Allen, 1941)

ULMER, F. A., JR. 1941. Kogia breviceps in South Carolina and New Jersey. Jour. Mamm., 22: 450–451.

YAMADA, MUNESATO. 1954. Some remarks on the pygmy sperm whale *Kogia*. Sci. Repts. Whales Res. Inst., 9: 37–58, figs. 1–13, 1 pl.

Institute of Marine Science, The University of Texas, Port Aransas; and *Scripps Institution of Oceanography, University of California, La Jolla.* *Received August 8, 1954.*

[Contributions from the Institute of Marine Science, and from the Scripps Institution of Oceanography (New Series, No. 768).]

NEW SAGEBRUSH VOLE, GENUS *LAGURUS*, FROM UTAH

BY LYLE C. DEARDEN AND M. RAYMOND LEE

In his MAMMALS OF UTAH, Durrant (Univ. Kansas Publs. Mus. Nat. Hist., 6: 1–549, 1952) listed *Lagurus curtatus intermedius* and *L. c. levidensis* as occurring in Utah. To the former he assigned a range including all of Utah west of 112° W Longitude, with the exception of the Bonneville Salt Flats, and to the latter, the northern slopes of the Uinta Mountains and the East Tavaputs Plateau.

Subsequently several specimens of this species were collected from the Aquarius and Fishlake plateaus of south-central Utah. These specimens were taken from areas where they were not previously known to occur and in ecological situations not generally regarded as their preferred habitat.

The inadequately known relationships among the named subspecies of this species have been commented upon by Hall (MAMMALS OF NEVADA, Univ. California Press, 1946: 561) and Durrant (*loc. cit.*: 380). Since the geographical variation of the sagebrush vole is so little understood and because of the fact that the majority of localities from which adequate series are available are "spotty" and widely separated, topotypes or near topotypes of all the named subspecies were obtained for comparative purposes. Critical comparisons of specimens herein

described as new with specimens of the named kinds leave no doubt that these specimens definitely merit naming and recognition as a new subspecies.

All measurements are in millimeters and capitalized color terms are from Ridgway (COLOR STANDARDS AND COLOR NOMENCLATURE, Washington, D. C., 1912).

Acknowledgements.—The writers acknowledge with thanks the kind loan of specimens for comparative purposes by: Dr. Ernest S. Booth, Walla Walla College; Dr. J. E. Moore, University of Alberta; Dr. Seth B. Benson, University of California; Miss Viola Schantz, U. S. Fish and Wildlife Service; and Dr. L. S. Russell, National Museum of Canada. This work was sponsored by a grant in aid from the National Science Foundation.

Lagurus curtatus orbitus new subspecies

Type.—Female, adult, skin and skull, number 9077, Museum of Zoology, University of Utah; Steep Creek, 15 miles north of Boulder, 8,500 feet, Garfield County, Utah; July 8, 1953; collected by M. Raymond Lee; original number 291.

Range.—Aquarius and Fishlake plateaus of south-central Utah. Limits unknown.

Diagnosis.—Size medium (see measurements). COLOR: General appearance of upper parts near Hair Brown with moderately heavy suffusion of black, hairs with 3 bands, basal Dark Neutral Gray, subterminal Pale Pinkish Buff, tip blackish brown; sides grayer; subauricular tuft of hair clear Light Ochraceous-Buff; tail distinctly bicolored; upper surface buffy with moderate sprinkling of black hairs, under surface whitish; fore and hind feet and entire underparts white; hairs of underparts Dark Neutral Gray basally except on chin. SKULL: Medium; markedly angular; interorbital region moderately depressed; interorbital constriction narrow; shape of zygomata at squamoso-jugal suture compressed and wide dorso-ventrally; fronto-premaxillary suture extensively interdigitated; braincase markedly small both in width and depth; tympanic bullae small and angular; mastoidal bullae both rugose and flattened.

Measurements.—Average and extreme measurements of 3 adult males, numbers 9076, 9075, 9002, two topotypes and one near topotype, and one female the type, number 9077, are, respectively, as follows: Total length, 124 (125–122), 133; length of tail, 16.7 (18–15), 17; length of hind foot, 16 (17–15), 16; length of ear, 11.3 (12–11), 12; basilar length, 20.9 (21.5–20.3), 21.8; length of nasals, 6.0 (6.2–5.7), 6.5; zygomatic breadth, 13.9 (14–13.9), 15.1; interorbital breadth, 3.0 (3.1–3.0), 3.0; length of orbit, 8.6 (8.7–8.6), 8.9; mastoidal breadth, 11.1 (11.3–11.0), 11.3; basicranial depth over bullae, 8.15 (8.2–8.1), 8.5; alveolar length of upper molars, 5.7 (5.6–5.8), 5.8.

Comparisons.—Topotypes of *Lagurus curtatus orbitus* differ from those of *L. c. intermedius* as follows: COLOR: Darker; slightly less buffy throughout; greater suffusion of black on dorsum; feet and undersurface of tail slightly lighter. SKULL: Proximal and distal ends of rostrum less depressed; interorbital region more depressed; zygomata heavier, and from a dorsal view appear more circular as opposed to oblong antero-posteriorly; braincase markedly smaller; tympanic bullae smaller, more angular and less inflated ventrally; incisors longer.

From topotypes and near topotypes of *L. c. levidensis*, topotypes of *L. c. orbitus* show the following differences: SIZE: Total length greater. COLOR: Darker, greater suffusion of black on dorsum; upper parts less buffy. SKULL: Larger, more robust; proximal end of rostrum (naso-frontal suture) less depressed; zygomata both markedly heavier and more bowed out laterally; braincase actually as well as relatively narrower; interorbital region less depressed; interorbital constriction narrower; upper incisors longer; basioccipital longer; tympanic bullae more angular and slightly less inflated ventrally; mastoidal bullae more rugose and slightly less inflated.

Topotypes of *L. c. orbitus* differ from near topotypes of *L. c. pauperrimus* as follows: SIZE: Total length and length of tail less. COLOR: Generally slightly darker, although some

specimens are indistinguishable. SKULL: Proximal end of rostrum less depressed; zygomata from a dorsal view appear more nearly circular as opposed to oblong antero-posteriorly; brain case narrower and less inflated; distal end of rostrum less depressed; upper diastema markedly shorter; interorbital constriction narrower; interorbital region more depressed; tympanic bullae markedly smaller; being both more angular and less inflated; mastoidal bullae more rugose.

From specimens of *L. c. pallidus* topotypes of *L. c. orbitus* differ as follows: SIZE: Total length and length of tail less. COLOR: Darker, greater suffusion of black on dorsum. SKULL: Shorter; distal and proximal ends of rostrum less depressed; nasals shorter; zygomatic breadth less; zygomata more circular from a dorsal view; alveolar length markedly less; orbit shorter; interpterygoid space wider and shorter; tympanic bullae markedly smaller and more angular; squamosal crests more pronounced; mastoidal bullae less inflated and more angular.

Compared to topotypes and near topotypes of *Lagurus curtatus curtatus* those of *L. c. orbitus* differ as follows: SIZE: Total length and length of tail smaller. COLOR: Darker; gray as opposed to grayish brown. SKULL: Zygomata more circular from a dorsal view; interorbital constriction markedly narrower; length of nasals less; mastoidal breadth less.

Habitat.—The sagebrush vole throughout much of its range appears to have a rather strong predilection for sagebrush. Moore (Canadian Field Nat., 67: 154–156, 1953: 155) reported collecting specimens of *L. c. pallidus* in southern Alberta in highland areas of scanty vegetation including grasses, cactus, sagewort and winter fat. James and Booth (Walla Walla Col. Publ., Dept. Biol. Sci. and Biol. Sta., 1 (2), 1952: 23) found animals of *L. c. pauperrimus* inhabiting the ecotone between the sagebrush and bunch grass vegetational belts in Washington. Representatives of *L. c. pauperrimus* occurred in two somewhat distinct habitats according to James and Booth (*loc. cit.*); one being where the bunch grass predominated and the other where sagebrush was the most abundant. Hall (Jour. Mamm., 9, 1928: 202) stated that animals belonging to *Lagurus curtatus* occurred on open grassy ridges, except in the Uinta Mountains, where they were found in grassy parks near the lower edge of the pine timber. In general, however, the habitat of this mammal is typified by the presence of sagebrush. In California and Nevada, according to Hall (*loc. cit.*) these mice were found only in certain types of sagebrush. Moreover, the majority of specimens taken in Utah have been collected among sagebrush.

It was with particular interest then, in the course of the present study, that these mammals were found living in a habitat other than sagebrush. Not a single specimen from the Aquarius Plateau was collected in sagebrush and with the exception of one specimen, all others were taken several miles from the nearest sagebrush.

The habitat of *L. c. orbitus*, more exactly defined, is characterized by open rocky hillsides or knolls supporting a rather sparse growth of grass. Both the specimens from the type locality and those from Spectacle Lake were taken in this type of habitat. The single specimen from Cowpuncher Ranger Station was taken in a moist grassy meadow among scattered birch (*Betula*). It is noteworthy that Spectacle Lake, at 10,500 feet, is the highest elevation at which these mammals are known to occur. No specimens were taken below 8,500 feet, and it appears that these mammals are ecologically restricted to a montane habitat.

Thus *L. c. orbitus* is not only morphologically distinct from other named kinds, but appears to occupy a different ecological habitat than its geographically nearest related forms.

Taxonomic remarks.—The combined features of the distinctively shaped zygomata and the small braincase make the members of this subspecies probably the most distinctive of the North American kinds. The only geographically contiguous subspecies to *L. c. orbitus*, as its range is presently understood, is *L. c. intermedius*. On geographical grounds, therefore, it would seem that *L. c. orbitus* should have its closest affinities with *L. c. intermedius*. Comparisons show, however, that *L. c. orbitus* actually has its closest affinities with *L. c. levidensis*. If *L. c. orbitus* is as restricted to a montane or semi-montane habitat as previous collecting has shown it to be, its relationship with *L. c. levidensis* is further substantiated.

It is known (Durrant, *loc. cit.*) that certain other montane kinds found on the High Plateaus of south-central Utah also have their affinities with animals inhabiting the Uinta Mountains and with the Coloradan fauna.

One specimen from the Fishlake Plateau is not typical of *L. c. orbitus*. It resembles *L. c. orbitus* in the size and angularity of the tympanic bullae, depressed interorbital region, and shape and construction of the zygomata. The size of the upper incisors and the width of the interorbital constriction show an approach towards the condition found in animals belonging to both *L. c. intermedius* and *L. c. levidensis*. Because of the similarities to *L. c. orbitus* in the mentioned characters this specimen is here referred to this subspecies.

The subspecific name *orbitus* is taken from the Latin word *orbitus* meaning circular and refers to the widely flaring, nearly circular appearing zygomata demonstrated by members of this subspecies.

Specimens examined.—Total 8, distributed as follows: SEVIER COUNTY: West of Skougaard's Resort, Fishlake, 9,000 ft., 1. GARFIELD COUNTY: Spectacle Lake 10,500 ft., 13 mi. S Teasdale, 2; Steep Creek, 15 mi. N Boulder 8,500 ft., 4; Cowpuncher R. S., 18 mi. N Escalante, 9,500 ft., 1.

Contribution from the Division of Biology, Department of Vertebrate Zoology, University of Utah, Salt Lake City, Utah. (Present address of Lyle C. Dearden, Department of Zoology, Fernald Hall, University of Massachusetts, Amherst.) Received July 24, 1954.

TWO NEW SUBSPECIES OF ANTELOPE GROUND SQUIRRELS FROM UTAH

BY RICHARD M. HANSEN

Many kinds of mammals reach their distributional limits in Utah. This is especially true of rodents restricted to montane or desert habitats. The diverse topography has been instrumental in developing many isolated or semi-isolated populations that have subsequently evolved into recognizable kinds. The central mountain ranges, beginning in northern and northeastern Utah, extend in a southern and southwestern direction. These mountains separate the deserts of the Lake Bonneville Basin from those of the Colorado Drainages of southern, southeastern and eastern Utah. Correspondingly, the desert areas in which antelope ground squirrels occur are also separated. In eastern and southeastern Utah, the Green and Colorado rivers, and their tributaries, with their deeply entrenched canyons, are also barriers that restrict gene flow between populations of antelope ground squirrels. In attempting to re-evaluate the effects of river systems and mountain barriers on the evolution and subspeciation of antelope ground squirrels in Utah, two populations were found that were beyond the range of variation found in the already known subspecies. These are here described as new subspecies.

Acknowledgements.—I wish to thank Dr. Stephen D. Durrant of the University of Utah for his supervision and helpful suggestions; the United States Public Health Service, Microbiological Institute for financial aid during the course of this study; the following persons and institutions for the loan of specimens: John Aldrich and Viola S. Schantz, U. S. National Museum, Washington D. C.; J. Kenneth Doutt and Caroline A. Heppenstall, Carnegie Museum, Pittsburgh,

Pennsylvania; Seth B. Benson, Museum of Vertebrate Zoology, University of California, Berkeley, California; Vasco M. Tanner and C. Lynn Hayward, Brigham Young University, Provo, Utah; Howard Knight, Weber Junior College, Ogden, Utah.

Methods.—Comparisons are of adult specimens unless otherwise indicated. Color comparisons are of summer pelage unless otherwise stated. Capitalized color terms are those of Ridgway (COLOR STANDARDS AND COLOR NOMENCLATURE, Washington, D. C. 1912). In the course of this study, a large series of topotypes of the various subspecies that occur in Utah were studied. In addition, specimens from surrounding states were examined. Unless otherwise indicated, specimens are in the Museum of Zoology Collections, University of Utah.

Citellus leucurus escalante new subspecies

Type.—Female, adult, skin and skull no. 9195, Museum of Zoology, University of Utah; 2 miles southeast of Escalante, 5400 feet, Garfield County, Utah; collected by M. Raymond Lee, August 19, 1953; original number 493.

Range.—Colorado drainages of Washington, Kane, Garfield and extreme western Wayne counties, Utah; limits unknown.

Description.—Average and extreme external measurements of 10 topotypes and near topotypes (6 females, 4 males) are as follows: 218 (205–234); 61 (56–65); 39 (36–42). COLOR—*Summer pelage:* Head, Light Vinaceous-Cinnamon; forepart of back gray; back and rump Cinnamon-Buff, with admixture of black on dorsal parts; underparts white; tail gray above, white beneath; lateral stripes white; shoulders and thighs between Pinkish Cinnamon and Cinnamon; eye ring, front and hind feet, Pale Pinkish Buff. *Winter pelage:* Grayer than summer pelage. SKULL: Occipitonasal length, 38.8 (37.1–39.4); length of bullae, 11.6 (11.4–11.7); zygomatic breadth, 23.4 (23.1–24.6); breadth of braincase posterior to temporal processes of zygomata, 18.8 (18.3–19.4); postorbital breadth, 13.8 (13.1–14.2); length of nasals, 10.8 (10.0–11.8); width between fronto-premaxillo-maxillary sutures, 9.0 (8.5–9.5).

Comparisons.—*C. l. escalante* may be distinguished from *C. l. leucurus* by redder color. They resemble *C. l. pennipes* in color, but are grayer and are less buffy than *C. l. cinnamomeus*. They have whitish colored feet and can be distinguished from all other subspecies except *C. l. leucurus* by this character.

The length of the nasals in *C. l. escalante* averages shorter than in any other subspecies in Utah. The skull, however, is large, exceeded in length only by *C. l. pennipes*. The bullae are smaller than those of *C. l. pennipes*. The rostrum is wide and the zygomatic breadth is as large as in *C. l. pennipes*. External measurements of all subspecies of *C. leucurus* are nearly the same; however, the tail length in *C. l. escalante* averages significantly shorter than in other subspecies.

Specimens examined.—Total, 54, from: WAYNE COUNTY: ½ mi. E Bicknell, 1; 2½ mi. E Bicknell, 2; 1 mi. E Bicknell, 1. KANE COUNTY: Kanab, 2; Willow Tank Spring, 3 (B.Y.U.). GARFIELD COUNTY: 8 mi. S Escalante, 5200 ft., 1; Henry Mts., Kings Ranch, 2; 9 mi. NE Hite, 1; Escalante, 1 (B.Y.U.); 2 mi. SE Escalante, 5400 ft., 2. WASHINGTON COUNTY: Leeds, 4 (B.Y.U.); Hurricane, 2 (B.Y.U.); Virgin, 1 (W.J.C.); St. George, 13 (3, B.Y.U.) (7, U.S.N.M.) (2, W.J.C.); Springdale, 4; Toquerville, 3 (2, U.S.N.M.); La Verkin, 1; Beaverdam Wash, 7; W slope Beaverdam Mts., 1; Santa Clara Creek, 1; West Mt. Reservoir, Beaverdam Mts., 1 (W.J.C.).

Citellus leucurus notom new subspecies

Type.—Male, adult, skin and skull, no. 9919, Museum of Zoology, University of Utah; Notom, Wayne County, Utah; collected by D. E. Beck, July 2, 1936; original number 5288 N.

Range.—Uinta Basin, west of Green River, San Rafael Swell, lower drainages of the Dirty Devil River in Emery and Wayne counties, Utah.

Description.—Average and extreme external measurements of 11 topotypes and near topotypes (6 males, 5 females) are as follows: 218 (204–232); 65 (59–69); 38 (35–41). COLOR—*Summer pelage:* Upperparts, Vinaceous-Cinnamon to Pinkish Cinnamon, specimens from near the type locality lack practically all black and white bands on hairs and are uniformly colored Vinaceous-Cinnamon; underparts, white; tail, gray above, white beneath; cheeks, Light Pinkish Cinnamon; eye ring, Pale Pinkish Buff; front and hind feet, Pale Pinkish Cinnamon; lateral stripes short and white; rump, same color as upperparts. *Winter pelage:* Upperparts vary from Light Vinaceous-Cinnamon to grayish admixture of white, black and Cinnamon-Buff; underparts, hairs, white terminally, black basally; front and hind feet, Pale Pinkish Cinnamon; black and white bands more frequent than in summer pelage. SKULL: Occipitonasal length, 39.0 (37.5–40.3); length of bullae, 11.5 (10.6–12.4); zygomatic breadth, 23.4 (21.8–24.6); breadth of braincase posterior to temporal processes of zygomata, 18.9 (18.0–19.4); postorbital breadth, 14.2 (13.4–15.0); length of nasals, 11.9 (11.7–12.3); width between fronto-premaxillo-maxillary sutures, 8.9 (8.4–9.3).

Comparisons.—Animals referable to *C. l. notom* may be distinguished from those of other subspecies by redder color, lacking practically all white and black bands of the hairs, on the head and dorsum. In areas where they do not intergrade with other subspecies, their upperparts are uniformly reddish-orange. Their nasals are as long as *C. l. cinnamomeus* and *C. l. pennipes*, but the rostrum appears to be proportionately shorter and resembles *C. l. escalante* in this character. The bullae are more globose than are those of *C. l. escalante*. The lateral white stripes are short and distinct.

Specimens examined.—Total, 47, from: UINTAH COUNTY: Pariette Bench, 8 mi. SW Ouray, 1 (C.M.); 7 mi. SW Jensen, N bank of Green River, 7 (C.M.); Sand Wash, 15 mi. SW Ouray, 5 (C.M.); 8 mi. S Vernal, 1 (C.M.); 12 mi. N Ouray, 2 (C.M.). DUCHESNE COUNTY: Antelope Canyon, 10 mi. SW Myton, 1 (C.M.); Bad Lands Cliffs, 15 mi. SW Myton, 2. CARBON COUNTY: N side Minnie Maud Creek, 2; between Wellington and Woodside, 1; Wellington, 1. EMERY COUNTY: Buckhorn Wash, San Rafael River, 3 (2, W.J.C.); 6 mi. N San Rafael River, 32 mi. SE Huntington, 3 (2, W.J.C.); 12 mi. SW Greenriver, 1 (C.M.); 10 mi. S Greenriver, 1; 16 mi. NW Greenriver, 3 (C.M.); Woodside, 1. WAYNE COUNTY: Hanksville, 1 (W.J.C.); 12 mi. W Hanksville, 1 (C.M.); Torrey, 3 (1, B.Y.U.) (1, C.M.); Capitol Reef National Monument, 5 (B.Y.U.); Notom, 2 (1, B.Y.U.); Fruita, 1 (B.Y.U.).

Remarks.—Antelope ground squirrels from the Lake Bonneville Basin of western Utah have been assigned to *C. l. leucurus* by previous workers. Howell (N. Amer. Fauna, 56, 1938: 171) assigned specimens from Washington County, Utah, to *C. l. leucurus*, and commented that they were intergrades between *C. l. leucurus* and *C. l. cinnamomeus*. Durrant (Univ. Kansas Publs., Mus. Nat. Hist., 6, 1951: 122–125) assigned specimens from southeastern Washington County to *C. l. cinnamomeus* and those from the remainder of the county to *C. l. leucurus*. He also considered squirrels from this area to be intergrades between *C. l. leucurus* and *C. l. cinnamomeus*.

In my studies, I also find that specimens from the Colorado River drainage of Washington County are intergrades, but they are all referable to the newly described subspecies *C. l. escalante*. The length of the nasals in the majority of specimens is less than 11.0 mm. and averages shorter than either those of *C. l. leucurus* or *C. l. cinnamomeus*. Some specimens have nasals that are as long as specimens of both *C. l. leucurus* and *C. l. cinnamomeus*, but their averages are closer to that of *C. l. escalante*. In color, these specimens are gray, but are more buffy than are typical specimens of *C. l. leucurus* from the Great Basin. This also leads me to believe that they are referable to *C. l. escalante* and not *C. l. leucurus*.

In the accounts of *C. l. cinnamomeus* from Utah, Howell (*loc. cit.* 174), Kelson (Univ. Utah Biol. Ser., 11 (3), 1951: 33) and Durrant (*loc. cit.* 122) all agreed that these squirrels occurred on both sides of the Colorado River in Utah. I find that the Colorado River is a barrier to antelope ground squirrels in southern Utah and that *C. l. cinnamomeus* is confined to that part of Utah which is south and east of the Colorado River. Specimens from

opposite sides of the Colorado River near Hite, Garfield County, are easily distinguished from each other. Those from south of the river are reddish and resemble *C. l. cinnamomeus* and those from north of the river are gray and resemble topotypes of *C. l. escalante*. As a group, all specimens from north of the Colorado River in Washington, Kane, Garfield and western Wayne counties are grayer, possess shorter nasals, and a wider rostrum than do specimens from south of the Colorado River in Utah. I, therefore, assign all specimens from the Colorado River drainage of Washington, Kane, and Garfield counties and the extreme western part of Wayne County to *C. l. escalante*. Specimens from Dewey, Grand County, Utah, south of the Colorado River are, however, intermediate between *C. l. pennipes* and *C. l. cinnamomeus* but referable to the latter.

An extremely interesting distributional and taxonomic problem exists in the Arizona Strip, north of the Colorado River, in Arizona. Five specimens from the U. S. National Museum from north of the Colorado River at Lee's Ferry agree in color and in cranial characters with topotypes of *C. l. cinnamomeus*. They are quite different, however, from specimens of *C. l. escalante* from further north in Utah. I would expect the Colorado River to be a barrier to antelope ground squirrels in this area. More specimens from other areas in the Arizona Strip will be needed before the relationship of these five specimens can be adequately determined.

Antelope ground squirrels from the lower drainage of the Dirty Devil River have been previously assigned, without consistency, to either *C. l. pennipes* or *C. l. cinnamomeus* (Howell, *loc. cit.*). With the acquisition of additional specimens from this area, it becomes apparent that animals from there do not belong to either subspecies but instead represent a new subspecies, *C. l. notom*, whose range includes the clay and sandy badlands of the Dirty Devil River drainage, the Uinta Basin west of the Green River and the San Rafael Swell area.

Specimens from the southern foothills of the Tavaputs Plateau, in the drainages of the San Rafael and Price rivers have previously been assigned to *C. l. pennipes*. Specimens from these areas are grayer than typical specimens of *C. l. notom* and in color show intergradation with *C. l. pennipes*. In most cranial characters, however, they are referable to *C. l. notom*.

Specimens from the Uinta Basin have been formerly assigned to *C. l. pennipes*. Specimens from the Uinta Basin, east of the Green River, are gray while those from west of the Green River are redder colored. Specimens from west of the Green River are grayer than typical specimens of *C. l. notom*, but in most cranial characters are intermediate between *C. l. notom* and *C. l. pennipes*. Specimens from east of the Green River, however, appear to be almost identical to topotypes of *C. l. pennipes* in cranial details. In color, however, they are even grayer than topotypes of *C. l. pennipes*. I have, therefore, assigned specimens from west of the Green River to *C. l. notom* and those from east of the Green River to *C. l. pennipes*.

Specimens from Grand County, Utah, north of the Colorado River, near the type locality of *C. l. pennipes*, were assigned by Kelson (*loc. cit.*: 35) to *C. l. cinnamomeus* and by Durrant (*loc. cit.*: 124) to *C. l. pennipes*. These specimens are identical in color with those from west of the Green River in the Uinta Basin. In most cranial characters, however, they resemble *C. l. pennipes*. I consider them to be intergrades between *C. l. notom* and *C. l. pennipes*, referable to the latter.

Intergradation between *C. l. notom* and *C. l. escalante* is evidenced in specimens from Capitol Reef National Monument and Fruita, Wayne County, Utah. The majority of the specimens are like *C. l. notom* in color and cranial details and are, therefore, referred to that subspecies. At Bicknell, Wayne County, Utah, all specimens are gray like *C. l. escalante* and their cranial characters prove them to be referable to that subspecies. Specimens from near Escalante and the Henry Mountains are the most typical of the subspecies *C. l. escalante*. It is interesting to note that an absolute barrier between *C. l. notom* and *C. l. escalante* does not exist although these two subspecies are two of the most distinct kinds. The area of intergradation between *C. l. notom* and *C. l. escalante* is narrow and abrupt, while the area of intergradation between *C. l. notom* and *C. l. pennipes* extends over a more extensive area.

Other subspecies of rodents in Utah have ranges that practically coincide with those of *C. l. escalante* and *C. l. notom*. For example, *Dipodomys ordii cupidineus*, *Peromyscus crinitus stephensi* and *Neotoma lepida monstrabilis* all have ranges that include the same area as *C. l. escalante*. *Dipodomys ordii sanrafaeli*, *Peromyscus crinitus doutti* and *Neotoma lepida sanrafaeli* are more northern and occupy the range ascribed to *C. l. notom*. While the boundaries of the ranges of the three other kinds do not correspond as closely to that of *C. l. notom* as do the ranges of the previously mentioned kinds to that of *C. l. escalante*, the ranges of all eight subspecies adjoin each other at approximately the same boundary. This apparent distinction between the ranges of subspecies of these areas caused Kelson (*loc. cit.*) and Durrant (*loc. cit.*) to recognize the areas as distinct subcenters in mammalian speciation.

Both workers thought that kinds having ranges corresponding to that of *C. l. escalante* had their closest affinities with animals to the west, while those from the north, with ranges corresponding to that of *C. l. notom*, apparently evolved *in situ*. From the study of antelope ground squirrels, I concur with their findings.

Apparently, during the ice ages and mountain building periods of the Pleistocene, continuous montane habitat, not suited to desert mammals, existed from northern Utah to northwestern Arizona. This most likely divided the ranges of the ancestors of the present kinds of antelope ground squirrels into eastern and western components. As concerns named kinds in Utah, the western component gave rise to *Citellus leucurus leucurus* and *Citellus leucurus escalante*, the eastern component has given rise to *Citellus leucurus cinnamomeus*, *Citellus leucurus pennipes* and *Citellus leucurus notom*.

Following the last retreat of the ice, the life zones now occur higher on the mountains. Aridity and the gradual warming of the area has subsequently allowed desert mammals to move eastward across the southern ends of the High Plateaus, and inhabit these previously inaccessible areas. Apparently, *C. l. escalante* evolved from the same ancestral stock as *C. l. leucurus*. Just recently the ranges of the previously isolated groups have come together, and this is, moreover, why the area of intergradation is so small and abrupt between *C. l. escalante* and *C. l. notom*.

Summary.—Two populations of antelope ground squirrels from Utah were found to possess characters that merited the describing of two new subspecies. The known ranges of the two new subspecies and the ranges, in Utah, for the three previously recognized subspecies are as follows: *Citellus leucurus escalante*, Colorado River drainages of Washington, Kane, Garfield and extreme western Wayne counties, Utah; *Citellus leucurus notom*, Uinta Basin west of the Green River, San Rafael Swell, lower drainages of the Dirty Devil River in Emery and Wayne counties, Utah; *Citellus leucurus leucurus*, all of the lower drainages of the Lake Bonneville Basin, Utah; *Citellus leucurus pennipes*, east of Green River and north of the Colorado River in Uintah and Grand counties, Utah; *Citellus leucurus cinnamomeus*, south and east of the Colorado River in Grand and San Juan counties, Utah.

Department of Zoology, University of Utah, Salt Lake City. Received July 25, 1954.

SKULL OF FOSSIL CAMELID FROM AMERICAN FALLS LAKE BED AREA OF IDAHO

By Marie L. Hopkins

Much camel material is present in the Idaho State College museum collection of vertebrate fossils. Since 1939 this material has been collected from various stratigraphic horizons, chiefly within a forty-mile radius of Pocatello. Included in the area of research are the Pleistocene American Falls lake beds as well as the alluvial deposits overlying these beds. Part of our camelid collection came from the gravel pit near American Falls, worked by Dr. J. W. Gidley and Dr. C. L. Gazin (1935). More recently we have opened quarries just above the old town site of American Falls in an area stripped during World War II by the Bureau of Reclamation. From the recent excavations we have collected many jaws, teeth and skeletal parts of camels, ranging in age from juvenile to aged.

The camelid skull, I.S.C. No. 1500, with which the present paper deals, is from a lower stratigraphic horizon than that of the American Falls gravel pits. It does not seem to be either *Camelops minidokae* or *Camelops hesternus*, the species that previous workers, Hay (1927) and Gazin (1935), have reported from southeastern Idaho.

Savage (1951) discusses the status of the genus *Camelops*. He concludes that the species that should be given zoological usage are *Camelops hesternus* (Leidy), *Camelops huerfanensis* (Cragin), *Camelops sulcatus* (Cope) and *Camelops minidokae* (Hay). Skull No. 1500 seems to be in the larger size range mentioned by Dr. Savage, viz., the *C. hesternus—C. huerfanensis* group.

The site where I found it in April, 1951, is about 621 yards up the beach of American Falls reservoir from a *Bison latifrons* skull (Hopkins, Plate I, 1951). Wave action had washed up the skull so that it lay 33 feet out from the base of the cliff with only the teeth and palate exposed above the muddy water. Alternate freezing and thawing had cracked the teeth and broken the fragile skull in countless places. Almost the entire palate with the typical *Camelops* dentition was recovered. The only teeth missing are the canines and the crowns of the third premolars. Fortunately the alveolar sockets of the former and the roots of the latter are intact, so there is no doubt as to the dental formula.

The dorsal part of the skull is represented by most of the left orbit, the interorbital portion of the frontals, the sagittal crest, the nasals, the fossa bearing portion of the maxillae inferior to the nasals, and both premaxillae undamaged except anteromedially.

The posterior part of the skull is represented by the basi-occipital and shows both occipital condyles flanking the foramen magnum. Laterally it shows the paroccipital processes and the bullar region as well as the squamous part of the temporal. From the latter the left zygomatic arch connects with the left orbit, which is only incomplete anteriorly.

In making the necessary comparisons before referring this skull tentatively to *Camelops huerfanensis* I have studied *C. hesternus* material from La Brea at the Los Angeles County Museum, and *Camelops* from both La Brea aud Irvington

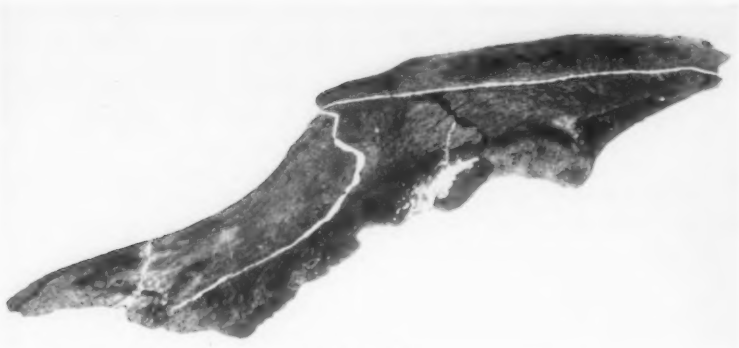


PLATE I

Camelops cf. *huerfanensis*.—Lateral view of left premaxilla showing its relation to the nasals and maxilla. Idaho State College Museum No. 1500.

faunas at the Museum of Vertebrate Paleontology of the University of California at Berkeley. While there, I also studied U.C.M.P. No. 22847, a recent *Camelus* skull. The data on *Camelops huerfanensis* used in making my comparison are entirely from the literature (Hay, 1912, 1913, 1921; Lull, 1921). Comparative summaries are given of the main characteristics in which this camelid differs or agrees with four different specimens of Pleistocene camelids (Table 1).

Compared to *Camelus* (Chauveaux, 1910; and U.C.M.P. No. 22847) it differs in dental formula, having no premolar present anterior to P^3 nor any trace of an alveolar socket for one. I^3 is definitely larger than the canine rather than the reverse as in *Camelus*. A deep maxillary fossa is present. The nasal borders are concave rather than sinuous.

A marked similarity to *Camelus* exists in the premaxillary-maxillary-nasal relationships of I.S.C. No. 1500. In neither of these forms is there broad contact between premaxillae and nasals. In fact, in the Idaho State College specimen a tiny wedge of maxilla prevents any contact between the bones in question. They barely touch in the University of California *Camelus* mentioned. Plate I shows a photograph in which the sutures between the premaxillary-maxillary and maxillary-nasals have been whitened. The zig-zag posterior boundary of the premaxillae resembles a reverse sigma of the Greek alphabet, and is well in front of the posterior margins of the anterior nasal apertures.

As compared with *Camelops hesternus* four important differences are noted. The posterior palatine foramina are not located as far anteriorly. They are opposite the anterior lobe of M^1 rather than P^4. The premaxillae have no connection with the nasals whereas in *C. hesternus* there is a broad connection. The nasal borders are concave rather than sinuous. The nasals are more highly arched.

Before discussing the similarities of our camelid with *C. huerfanensis* I should like to point out that with respect to relative height of the crowns of the teeth above the roots ours has less than the type *C. huerfanensis* (Cragin). This state

TABLE 1.—*Comparison Idaho State College camelid No. 1500 with Camelops species in its size range*

	Camelops hesternus U. C. 20040	*Camelops hesternus* U. C. M. P. 20028	*Camelops* cf. *huerfanensis* I. S. C. 1500	*Camelops huerfanensis* holotype U. S. N. M. 7819	*Camelops huerfanensis dallasi* S. M. U. 1.51
I^3 height	—	—	L. 27 crown	—	—
I^3 depth alveolus	—	—	L. 40 root	40	—
I^3 length (anterior-posterior)	17.8	—	L. 21.5	20	—
I^3 width—transverse	9.7	—	L. 16.5	—	—
Superior canine height	—	—	—	—	—
Superior canine length	13.2	13.9	R. 20.5†	—	—
Superior canine width	—	—	R. 11.4†	—	—
P^2 height	—	—	—	—	—
P^2 length	18.8	—	L. 11†‡	18.8	21
P^2 width	11	—	L. 17†‡	11	—
P^4 height	—	—	R. 36	38	—
P^4 length	28 at base	20–21**	L. 24.6	25	27.3
P^4 width	22.5	R. 25; L. 23.7**	L. 24*	25	—
M^1 height	—	—	R. 28.5	35	—
M^1 length	42	24.4	L. 31.4	38.5	37
M^1 width	33.6	31–**	L. 28.4*	30	—
M^2 height	—	—	L. 41	57	—
M^2 length	52	42.1–**	L. 47±	48	42.5
M^2 width	32.8	31.6	L. 31	30	—
M^3 height	—	—	L. 46.8	62	25.5±
M^3 length	45.8	49.5	L. 50±	45	52
M^3 width	27.2	31.4	L. 30	28.5	27
P^2-M^3	—	—	L. 172±	171	172.5
P^4-M^3	156.4	142.7	L. 158	152	154.5
M^1-M^3	132	124	L. 132	129	129
Distance between I^3 and canine	—	—	R. 12; L. 14	23	R. 18; L. 16
Postion posterior palatine foramen	Opposite P^4	Opposite P^3	Opposite M^1	Opposite M^1	Opposite M^1
Palate width between P^4	56	66	46±	50	40
Palate width in front M^2	—	—	95±	87	69
Distance premax. border to rear of M^3	322	324.5	343±	—	340

Teeth measured according to Hay (1913) p. 272; height according to Hay (1912) p. 235.

* Estimated after mending—not including mending matrix.

** Measurements furnished by Dr. D. E. Savage.

† Estimated from alveoli; or roots only.

‡ Tooth aligned more transversely than on opposite side.

of wear seems to indicate that ours is an older animal and would account for the anterior-posterior length being less in all the cheek teeth up to M^3, and for the slightly greater length of that tooth (Table 1).

With respect to those characters that Savage (1951) lists as differentiating the species *Camelops huerfanensis*, the only point of variance of our camelid is in the angle of the metastyle on M^3. Instead of being "bent sharply mesiad" ours seems to continue posteriorly as in *C. hesternus*. Whether a metastyle was present or seemingly absent on M^3 did not deter Merriam (1913) from classifying both No. 20028 and No. 20040 from Rancho La Brea as *C. hesternus*. Perhaps, though, he found that to be merely an age variation. The anterio-posterior alignment of P^3, as judged from roots only, seemingly differs on the right and the left sides of the palate of our specimen. Perhaps that fact explains the relative length-width variation as compared with the type of *C. huerfanensis*, as I measured the more complete one, the one aligned transversely.

The premaxilla of our skull is in size and shape practically identical with that of the type specimen. The distance from the rear of I^3 to the front of the canine is 12 mm. on the right side and 14 mm. on the left. This is less than in *C. huerfanensis dallasi* (Lull, 1921) and well within the limit of the type of the species. To quote Hay (1912: 235) in his description of the type of *C. huerfanensis*, "On the lower edge of the bone (pl. XXIX, fig. 40), is seen the smooth surface which formed a part of the front wall of the socket of the canine. This must have been a tooth of considerable size and its front border could have been hardly more than 23 mm. from the incisor." In none of the former finds of *C. huerfanensis* has the premaxillary-maxillary-nasal relationship been revealed.

If No. 1500 is an individual of the species *Camelops huerfanensis*, it exhibits in its premaxillary-nasal relationship an un-*Camelops*-like character which so far as I can determine has not as yet been described, and which is more *Camelus*-like. While I realize that genera of mammals such as, for example, *Bos-Bison*, have been separated largely on the basis of differences of this kind, I do not consider that I am well enough versed in taxonomy to suggest a change of genus. I merely call the attention of the taxonomists to the possibility that this may have been a characteristic of the camelids which have been classified *Camelops huerfanensis*.

It is upon the following evidence that I base my belief that I.S.C. camelid No. 1500 is from the Pleistocene American Falls lake beds rather than from a more recent but lower stream terrace. In spite of a rapid rate of cliff erosion that the annual fill of the reservoir induces, the cliff-beach relationship has presented a relatively unchanging picture during the fifteen years that I have studied this shoreline. For the past seven years sizeable field parties under my direction have combed this strip of beach and cliff for fossils, both before and after each high water. Since the skull was not visible the previous Fall it probably washed up as the water rose again.

According to Stearns (1938), the cliff adjacent to the beach where I.S.C. No. 1500 was found is part of the American Falls lake bed series. The rate of erosion of the cliff on this shore of the reservoir has been measured as about eighteen

feet a year. When found, the camelid skull lay only thirty-three feet from this relatively sheer cliff. This position, in view of such an erosion rate, seems to indicate the probability that only a few years prior to discovery it lay in the sand layer with the clay strata of the cliff directly above it. To explore further the theory that the cliff rests upon the sand of the upper beach, an excavation was made in one spot and the sand layer traced under the cliff. Obviously a more careful check in many places will be required before this can be proved conclusively. Also much more work on both the stratigraphy and the associated fauna remains to be done before any final conclusion can be drawn as to the subdivisions of the Pleistocene that are represented by the various levels from which our collections are being made.

Acknowledgments.—I am indebted to Dr. Donald E. Savage and Dr. Wann Langston for permitting me to study the La Brea and Irvington fauna in the Museum of Vertebrate Paleontology of the University of California; and to Dr. Savage for subsequently furnishing me with measurements of P^4–M^2 of the specimen of *C. hesternus* (U.C.M.P. No. 20028), and with the measurements on the Irvington *C. minidokae* (U.C.M.P. No. 38447).

I am also indebted to Dr. Hildegarde Howard and Dr. Theodore Downs of the Los Angeles County Museum for permission to study camelids from the La Brea collection there. I am grateful to the following of my colleagues at Idaho State College who assisted in the field work mentioned in this paper: Miss Dorothy Faris, Mrs. John Stones, Mrs. William Kitaj, Dr. William P. Kitaj, Mr. Ralph Rowell, Mr. A. L. Lillibridge and Mr. John Stones. For the photography I am indebted to Dr. R. A. Lyman and Dr. Edson Fichter.

LITERATURE CITED

Chauveaux, A. 1910. The comparative anatomy of the domesticated animals. D. Appleton and Company, 1046 p.

Gazin, C. L. 1935. Annotated list of Pleistocene Mammalia from American Falls, Idaho. Jour. Washington Acad. Sci., 25: 297–302.

Hay, O. P. 1912. The Pleistocene mammals of Iowa. Iowa Geological Surv., 23: 1–501.

———. 1913. Camels of the fossil genus *Camelops*. Proc. U. S. Nat. Mus., 46: 267–277.

———. 1921. Descriptions of species of Pleistocene vertebrates, types or specimens of most of which are preserved in the United States National Museum. Proc. U. S. Nat. Mus., 59: 519–642.

———. 1927. The Pleistocene of the western region of North America and its vertebrated animals. Carnegie Inst. Washington, Publ. 322B, 346 p.

Hopkins, M. L. 1951. *Bison* (*Gigantobison*) *latifrons* and *Bison* (*Simobison*) *alleni* in Southeastern Idaho. Jour. Mamm., 32: 192–197.

Lull, R. S. 1921. Fauna of the Dallas sand pits. The Amer. Jour. Sci., Fifth Series, 2: 159–176.

Merriam, J. C. 1913. The skull and dentition of a camel from the Pleistocene of Rancho La Brea. Publ. Papers and Addresses of John Campbell Merriam, Carnegie Inst. Washington, Vol. II, 500: 811–819.

Savage, D. E. 1951. Late Cenozoic vertebrates of the San Francisco Bay Region. Univ. California Publ. Bul. Depart. Geological Sci., 28: 215–314.

Stearns, H. T., L. Crandall, and W. G. Steward. 1938. Geology and ground-water resources of the Snake River Plain in Southeastern Idaho. U. S. G. S., Water-Supply Paper 774: 1–268.

Department of Zoology, Idaho State College, Pocatello. *Received April, 1954.*

GENERAL NOTES

ELECTROCARDIOGRAM OF THE RACCOON

During a course of studies on the comparative physiology of the heart, electrocardiograms were made of a single raccoon, *Procyon lotor lotor* (Linnaeus). Apparently, no such recordings have been published previously (Lepeschkin, MODERN ELECTROCARDIOGRAPHY, Williams and Wilkins, 1951). It, therefore, seemed appropriate that such data be made available to interested mammalogists.

The raccoon was lightly anesthetized with nembutal. Needle electrodes were inserted into the limb muscles. The V lead electrode was a needle inserted into the chest muscles just over the sternum and midway between the manubrium and xiphisternum. The animal was kept in the supine position. Room temperature was 24°C.; the raccoon's colonic temperature, 37°C.

Table 1 summarizes the values obtained for the various leads recorded. Table 2 gives comparative values for other mammals as reported in the literature. The direction of the electrical axis of the heart was +37, a value that would be considered normal in human clinical practice.

It is apparent that the electrocardiogram of the raccoon resembles that from other mammals having similar heart rates, e.g. guinea pig or rabbit. If the values for Q-T interval (total duration of ventricular activity) in Tables 1 and 2 are plotted against the logarithms of the heart rates, a straight line is obtained that indicates that, at faster heart rates, the Q-T interval is shortened. A similar straight line is obtained if P-R (time for conduction of heart activity from sinus node to ventricles) is plotted against heart rate. The R-R interval is .30 second. If the values for the raccoon are substituted in Bazett's square root formula, $QT = K.\sqrt{R\text{-}R}$ (Bazett, Heart, 7: 353, 1920), the value of K is found to be .29

TABLE 1.—*Electrocardiogram values for ten different leads taken on the raccoon*

Lead	Rate	P-R sec	Q-T sec	QR mv	QRS sec	T mv	T sec	P mv
I	200	.06	.16	.8	.03	.2	.10	.1
II	200	.06	.16	.8	.03	.2	.10	.2
III	200	.06	.16	1.0	.03	.1	.10	.05
AVR	200	.06	.16	0.75	.03	−.2	.10	−.1
AVL	200	.06	.16	0.75	.03	.05	.10	.05
AVF	200	.06	.16	0.70	.03	.2	.10	.1
V	200	.06	.16	2.6	.03	.6	.12	.05
CR	200	.06	.16	3.1	.03	.8	.12	.2
CF	200	.06	.16	2.5	.03	.45	.12	<.05
CL	200	.06	.16	2.8	.03	.55	.12	.05

TABLE 2.—*Electrocardiogram values for various mammals as reported in the literature*

Species	Rate	P-R sec	Q-T sec	QR mv	QRS sec	T mv
Bat	660	.03	—	—	—	—
Mouse	635	.04	.03	0.7	.02–.04	.07–.1
Rat	490	.05	.06–.08	0.46		.11
Guinea pig	200	.07	.13	.67	.01–.05	.06
Rabbit	250	.05–.1	.12	.33	.02–.04	.08
Horse	38	.30	.54	—	.12	—

for the raccoon as compared with .37 for men. Similarly, Ashman's logarithmic formula, $QT = K. \log [10(R\text{-}R + 0.07)]$, may be used (Ashman, Proc. Soc. Exp. Biol. Med., 40: 150, 1939). This formula gives a K value of .28 for the raccoon as compared with K = .37 for men.

Continuing comparative studies are in progress on the electrical activity of the heart in mammals.—CHARLES G. WILBER, *Chemical Corps Medical Laboratories, Army Chemical Center, Maryland.* *Received July 2, 1954.*

ELECTROCARDIOGRAPHIC STUDIES ON THE OPOSSUM

The structure of the conducting system in the heart of marsupials has been described in some detail (Blair, Davies, and Francis, 1942). The general cardiac anatomy of the native American opossum was reported by Wade and Neely (1949). Nardone and Wilber (1952) described the electrocardiographic changes that take place in the opossum exposed to low temperatures. They do not, however, give an adequately detailed description of the normal values. No information other than this is contained in the ordinarily available literature concerning the functional aspects of the opossum heart (Lepeschkin, 1951; Prosser, 1950; Hartman, 1952). The present paper reports the results of electrocardiographic studies on the opossum, *Didelphis marsupialis*, and includes data concerning the effects of decamethonium on the heart.

Ten animals were involved in these experiments. All, except one, were lightly anesthetized with nembutal before use. One was unanesthetized to ascertain the effect, if any, of the nembutal on the electrocardiogram. Needle electrodes were inserted into the limb muscles. The V lead electrode was inserted into the muscles just to the left of the sternum and midway between the omosternum and xiphisternum. A direct writing electrocardiograph was used.

After a control record was taken, 10 mg. of decamethonium bromide was injected intraperitoneally into one opossum and further records through lead II were made 1, 2, 3, 5, 8, and 9 minutes after the injection.

Table 1 summarizes the results of the records taken on anesthetized animals. The average colonic temperature of the opossums used in the present work was 34 ± 1°C. Hartman (1952) reports that the internal temperature varies between 95–97°F. The one unanesthetized opossum gave the following values for the electrocardiogram (lead II): rate 160, P-R, .06; Q-T, .16; QRS, .03; QR, 1.4 mv.; T, .1 mv., .08 sec; R-R, .36. It is apparent that light nembutal anesthesia does not induce significant changes in the opossum electrocardiogram (Table 1).

Several equations are often used to express the relation of the Q-T (total duration of ventricular activity) to the R-R interval (Lepeschkin, 1951). One of them is the so-called

TABLE 1.—*Average electrocardiogram values for ten different leads taken on the opossum. Light nembutal anesthesia*

Lead	Rate	P-R sec	QRS sec	QR mv	Q-T sec	T mv	T sec	P mv	R-R
I	200	.08	.02	.6	.14	.1	.06	.01	.32
II	200	.08	.03	1.7	.14	.1	.08	.01	.32
III	200	.08	.03	1.0	.14	<.05	.06	<.01	.32
AVR	200	.08	.02	−1.1	.14	−.1	.08	.01	.32
AVL	200	.08	.02	−.4	.14	.05	.08	<.01	.32
AVF	200	.08	.02	1.5	.14	.1	.08	.01	.32
V	200	.08	.03	2.6	.14	.15	.08	.05	.32
CR	200	.08	.03	3.2	.14	.25	.08	.05	.32
CF	200	.08	.02	1.7	.14	.1	.08	.01	.32
CL	200	.08	.03	2.8	.14	.1	.06	.05	.32

TABLE 2.—*Values on the electrocardiogram from the opossum after injecting 10 mg. of decamethonium bromide. Lead 2. Nembutal anesthesia. Colonic temp. 33°C.*

Mins. after Injection	Rate	P-R	Q-T	QRS	QR mv.	T mv.	T sec	P mv.	R-R
Control	175	.08	.14	.03	1.6	.15	.12	.01	.32
1	175	.08	.16	.03	1.8	.15	.08	.01	.36
2	175	.08	.16	.03	1.8	.20	.10	.01	.36
3	175	.08	.16	.03	1.8	.21	.08	<.01	.38
5	110 & falling	.08	.18–.20	.02	1.2	.75	.16	<.01	.58
8	80	.08	.06	.02	1.1	1.1	.16	<.01	.76
9	Irregular†	.08*	.08	.02	1.1	1.0	.16	<.01	—

* In many cycles there are 2 P waves before a QRS and the P has become diphasic.

† The atrial rate was 70 per minute. The ventricular rate varied with no apparent pattern from 30 to 70 per minute.

square root formula, (see above). By substituting values from Table 1 in this equation, K for the opossum is found to be 0.245. For man it is 0.37. Another equation is the logarithmic formula (see above). K for the opossum was found to be 0.237. For man, K is 0.385.

Table 2 shows the results of injecting 10 mg. of decamethonium bromide on the electrocardiogram of the opossum. For about three minutes after the injection no change in heart rate was observed. Thereafter, the ventricular rate dropped until it became very irregular at nine minutes after injection. The animal was cyanotic and maintained an irregular ventricular rate for several hours. The day following the injection, the opossum had recovered completely. The P-R interval, which is the time for conduction of the impulse from the sinus node to the ventricles, was unchanged by the drug. However, nine minutes after the injection many of the QRS complexes were preceded by two P waves and the P waves had become diphasic. At this time the P waves occurred regularly about 70 times per minute but were not always followed by a QRS-T complex. A picture of complete atrio-ventricular dissociation, with an irregular idioventricular rhythm, developed about nine minutes after injection of the decamethonium.

The abnormal appearance of the P waves indicates some abnormality of the atrial musculature (Riseman, 1952) following treatment with decamethonium. The abnormal QRS-T rhythm may originate in the ventricular muscle. It might also indicate a partial *block* of the impulse between atria and ventricles as a result of the drug.

The values for K calculated from the square root formula are: before injection of decamethonium, 0.245; 1 to 4 minutes after injection, 0.266; 5 minutes after, 0.263; 8 minutes after, 0.069. K calculated from the logarithmic formula had the following values: before injection, 0.237; 1 to 4 minutes after, 0.252; 5 minutes after, 0.233; 8 minutes after, 0.065.

Decamethonium is a member of the polymethylene bistrimethyl ammonium series of

TABLE 3.—*Effect of various drugs on the mammalian electrocardiogram. Decamethonium tested on opossum; other drugs as reported for various mammals in the literature (vid. Lepeschkin, 1951). +, increase; −, decrease; 0, no change; ...., no data*

Drug	Rate	P-R	P	T
Acetylcholine	−	+	−	+
Mecholyl	−	±	....	−
Prostigmine	−	+	−	+
Atropine	+	−	+	−
Decamethonium	−	0	−	+

compounds. It closely imitates acetylcholine at the neuromuscular junction in many species (Paton and Zaimis, 1952). In animals, acetylcholine induces a lengthening of the P-R and a depression of the P wave. Neither of these results were obtained after the administration of decamethonium in the opossum. In animals, small doses of acetylcholine cause elevation of T; 10 mg. of decamethonium caused an elevation of the opossum T and an increase in duration of the T. Table 3 compares the effects of decamethonium on the opossum heart with those of other drugs on mammals.

The electrocardiographic values found for the opossum are essentially similar to those reported for other mammals with similar heart rates (Lepeschkin, 1951). Blair, Davies and Francis (1942) conclude that the cardiac conducting system in the marsupials has essentially the same morphology as in all other homothermal vertebrates. The present results indicate that (physiologically) the opossum heart is not dissimilar to that of Eutherian mammals.

LITERATURE CITED

BLAIR, D. M., F. DAVIES AND E. T. B. FRANCIS. 1942. The conducting system of the marsupial heart. Trans. Roy Soc. Edin., 60: 629–637.

HARTMAN, C. G. 1952. Possums. Univ. of Texas Press, Austin. 174 p.

LEPESCHKIN, E. 1951. Modern Electrocardiography, Vol. I. The P-Q-R-S-T-U Complex. Williams and Wilkins, Baltimore. 598 p.

NARDONE, R. M. AND C. G. WILBER. 1952. Electrocardiograms of the opossum at low temperatures. Federation Proc., 11: 112.

PATON, W. D. M. AND E. J. ZAIMIS. 1952. The methonium compounds. Pharmacological Reviews, 4: 219–253.

PROSSER, C. L. (ed.). 1950. Comparative animal physiology. Saunders, Philadelphia.

RISEMAN, J. E. F. 1952. P-Q-R-S-T. A guide to electrocardiogram interpretation. Macmillan, New York. 123 p.

WADE, O. AND P. NEELY. 1949. The heart and attached vessels of the opossum, a marsupial. Jour. Mamm., 30: 111–116.

CHARLES G. WILBER, *Chemical Corps Medical Laboratories, Army Chemical Center, Maryland.* *Received July 31, 1954.*

A SIMPLE PERMANENT LIVETRAP PLOT FOR SHREWS

The author has experienced considerable difficulty in successfully live-trapping shrews in the boreal forest of eastern Manitoba. Using the Sherman livetrap it was found that unless the traps were examined at hourly intervals, the mortality in *Sorex cinereus* and *S. arcticus* was 100 per cent. Recently however the Sherman trap was replaced by tumble-in traps constructed by removing the tops of clean imperial-quart oil cans. These are then imbedded grid fashion on the plot flush with the ground level and baited with raw liver or ground beef. Captured animals are easily removed by removing the trap and inverting it into a plastic food bag where the animal is either marked and released or transported to the field laboratory. In the majority of cases, animals taken by this method were alive and well after remaining in the traps until the following morning. When the operator wishes to terminate trapping for any period, the oil cans are merely inverted in the hole so that the bottom of the can remains flush with the ground. The method has the advantage of less mortality even in light rainstorms and the cost of the trap is negligible. It further eliminates transporting the heavy and bulky Sherman trap. Juvenile *Microtus* and *Clethrionomys* can also be successfully taken in this manner, but a deeper trap is required for such forms as *Zapus* and *Peromyscus*.—C. H. BUCKNER, *Forest Biology Laboratory, Winnipeg, Canada.* *Received July 28, 1954.*

A RECORD OF THE SMOKY SHREW, *SOREX F. FUMEUS* MILLER, IN SOUTH CAROLINA

Sorex fumeus fumeus Miller has been taken at only a single locality in South Carolina. This record is of two individuals, taken in Jones Gap, (elevation 3000 feet), Greenville

County, in November, 1941 (Coleman, Jour. Mamm., 29: 293). Specimens of this species from southern localities appear to be rare in collections. Jackson (N. Amer. Fauna, 51: 64–65) lists one specimen from Brasstown Bald (altitude 4700 feet), Georgia, and twenty specimens from Roan Mountain and its vicinity, at altitudes varying from 6000 to 6300 feet, in North Carolina. Odum (Jour. Mamm., 30: 187) mentions taking seven specimens in the region of Highlands, Macon County, North Carolina; these were secured at localities whose altitude varied from 3900 feet to 4120 feet. Brimley (Carolina Tips, 1944–46: installment 3, first unnumbered page) mentions collecting an individual at Spruce, Haywood County, North Carolina. I am unable to find this locality on any map, but since Haywood County lies in the southern Blue Ridge section, the elevation whence the specimen was taken was presumably high. Komarek and Komarek (Bul. Chicago Acad. Sci., 5: 146–147) took twenty-five specimens of *Sorex f. fumeus* in the Great Smoky Mountains; they report that this shrew occurs there from an altitude of 2900 feet to the tops of the highest peaks, including Clingman's Dome (6642 feet) and Mt. Kephart (6200 feet).

A specimen of *Sorex f. fumeus* was taken by me at Jocassee, Oconee County, South Carolina. Since this is the second locality where this shrew has been collected within the state, and since the place where it was secured is at exceptionally low elevation for this species in the southeast, it seems worthy of record. The specimen was found dead on May 15, 1954, on a path near the Whitewater River; the anterior portion of the individual had been almost completely devoured by ants. However, the complete posterior portion of the animal was intact and in a good state of preservation; the freshness of the carcass was interpreted as indicating that the shrew had been killed on the previous night by some predator. The bicolor tail which measures 43 mm., the concolor dorsal and ventral surfaces, and the hind feet measuring 13 mm., all serve to identify the specimen as *Sorex fumeus*; a trinomial is employed because of the provenance of the specimen. The individual is a female and the pelage is gray, the typical coloration of this shrew in winter.

The elevation at Jocassee is approximately 1000 feet. This is the lowest elevation at which the smoky shrew has been recorded in the southeast and is considerably lower than the lowest elevation (2900 feet) recorded by Komarek and Komarek for the occurrence of this shrew in the Great Smoky Mountains. The Jocassee locality is exceeded only by Jackson's Brasstown Bald, Georgia, record as a southernmost place for the collection of this species. As a general rule, boreal forms occur in the south only at high elevations (*Synaptomys cooperi*, *Tamiasciurus hudsonicus*, *Clethrionomys gapperi*, for example, and many others), and it is quite unusual to find the boreal *Sorex f. fumeus* occurring at such a low elevation. Jocassee lies on the Whitewater River, and in this immediate region the Piedmont and Blue Ridge provinces abutt upon each other, and interdigitate. Valley floors and exposed hillsides have Piedmont floral and climatic affinities, while the shaded western side of the Whitewater River Valley supports a lush shady growth of rhododendron and mountain laurel. Several spring-fed streams with moss-covered rocks, and spring seepages, make for excellent shrew habitat. Locally these streams cut steepsided but relatively shallow ravines, which are well shaded with rhododendrons, and are moist and cool even in the heat of the summer. Montane forms can persist in these sheltered areas, and that they undoubtedly have is attested by the occurrence there of the smoky shrew. The present specimen was found immediately adjacent to such a ravine.

The source of this low-elevation population of *Sorex f. fumeus* has certainly been from the north. The Whitewater River begins across the North Carolina line in regions not too far distant from Odum's North Carolina localities for *Sorex f. fumeus*. The Toxaway River, which joins the Whitewater River just south of Jocassee to form the Keowee River, also has its source in North Carolina at high elevations (undoubtedly in smoky shrew areas). The steep gorges that these rivers form as they cut down through the Blue Ridge into the Piedmont are virtually unknown faunistically because of their inaccessibility, and would form an excellent avenue for small mammals, as typified by shrews, to reach lower elevations. There they may persist in particularly favored local situations.—ALBERT SCHWARTZ. *The Charleston Museum, Charleston 16, South Carolina.* *Received June 20, 1954.*

CONDYLURA CRISTATA FROM THE COASTAL PLAIN OF SOUTH CAROLINA

On the morning of April 3, 1954, two of our local boys, James Taylor and Ken Brown, brought a live but seriously injured star-nosed mole (*Condylura cristata*) to the house. They had retrieved the animal from a cat in a neighbor's yard. The locality was on South Island Road, 2½ miles south of Georgetown, Georgetown County, South Carolina. The animal was an immature male: total length 165 mm., tail 58 mm., hind foot 25 mm., testes 4 mm.

This apparently is the first record for the species in South Carolina since it was recorded by Burnett in 1851 (Proc. Boston Soc. Nat. Hist., 4: 115–118). That record was for Upper South Carolina, thus the present record seems to be the only one from the Coastal Plain.

The specimen has been deposited in the Charleston Museum, Charleston, South Carolina. —WILLIAM C. GRIMM, *Route 2, Box 122-B Georgetown, South Carolina. Received April 18, 1954.*

MYOTIS AUSTRORIPARIUS IN ARKANSAS

Myotis austroriparius has not been recorded from the region between central Louisiana and southern Illinois. Two specimens of this species in the mammal collection of the University of Arkansas (U.A.Z., nos. M52-27 and M52-29), taken by F. B. Truett on November 27, 1952, in an abandoned mine shaft twelve miles northwest of Hot Springs, Garland County, Arkansas, extend the known range of *Myotis austroriparius* 200 miles to the north of the nearest locality from which the species was previously known to occur, *viz.*, Vowell's Mill, Natchitoches Parish, Louisiana. Furthermore, the record is 360 miles south-southwest of the nearest Ohio Valley records. *Myotis austroriparius* is known from Mitchell, Indiana, and from four localities in Hardin County, Illinois (as determined by specimens in the University of Illinois Museum of Natural History and the collection of the Illinois Natural History Survey).

The artificial shaft from which the specimens were collected in Arkansas was about five feet wide, six feet high, and about 300 to 400 feet long with an exterior opening approximately two feet in diameter. The shaft was located near the spillway of Blakely Dam, which was under construction at the time the specimens were collected, and the shaft has since been inundated by impounded water. Other mine shafts in the near vicinity still remain open, however. At the time the specimens were collected for identification, at least a dozen *Myotis* and a few pipistrelles, *Pipistrellus subflavus*, were present in the mine tunnel. In addition to the *M. austroriparius*, Mr. Truett collected a *Myotis lucifugus* (U.A.Z. no. M52-28) and two *Myotis keenii* (U.A.Z. nos. M52-30 and M52-31). On December 23, 1952, he banded six males and four females of an unidentified *Myotis*. None of them showed any signs of dormancy. On January 1, 1953, he again entered the mine shaft and found only four bats, which were dormant pipistrelles.

The writers have compared the Arkansas specimens with near topotypes of *Myotis austroriparius austroriparius* Rhoads from Florida, with the type and paratypes of *Myotis austroriparius gatesi* Lowery from Louisiana, and with specimens from Illinois and Indiana. It is evident that *M. austroriparius* is a species exhibiting considerable variation in color and size. For this reason it was thought advisable to defer the subspecific assignment of the Arkansas specimens until a taxonomic revision of the species is completed. Such a revision is at present being undertaken by other workers.—WAYNE H. DAVIS, WILLIAM Z. LIDICKER, JR., AND JOHN A. SEALANDER, JR., *Museum of Natural History, University of Illinois, Urbana, and Department of Zoology, University of Arkansas, Fayetteville. Received June 30, 1954.*

MYOTIS SUBULATUS LEIBII IN MISSOURI

Myotis subulatus leibii is known from as far west as Colossal Cave in the Mammoth Cave region of Kentucky (Bailey, V., CAVE LIFE OF KENTUCKY, p. 80, 1933). *M. s. subulatus* is known from as far east as Trego County, in western Kansas (Cockrum, E. L., MAMMALS OF KANSAS, p. 63, 1952). The species *Myotis subulatus* has not been recorded from between

these two areas. The discovery of a specimen of the eastern race (*M. s. leibii*) from three miles south of Graniteville, Iron County, Missouri, helps to fill in this gap in the known distribution of the species. In addition, it is the first recorded occurrence of *M. s. leibii* west of the Mississippi River. The specimen was taken by P. W. Smith on October 9, 1949, and is in the collection of the University of Illinois Museum of Natural History (no. 599).

This individual was compared with specimens of *M. s. leibii* from West Virginia, with *M. s. subulatus* from Kansas, and with *M. s. melanorhinus* from Arizona. It can be assigned, with little doubt, to *M. s. leibii*.—Wayne H. Davis and William Z. Lidicker, Jr., *Museum of Natural History, University of Illinois, Urbana.* *Received June 11, 1954.*

STATUS OF *MYOTIS GRISESCENS* IN FLORIDA

Myotis grisescens has previously been reported in Florida by Sherman (Jour. Mamm., 15: 156, 1934) on the basis of two specimens shot while they were flying over the Chipola River just north of the town of Marianna, Jackson County, on the evening of June 9, 1930. On May 8 and 9, 1954, while engaged in investigations of *Myotis austroriparius* in the Marianna region, in company with a Florida Speleological Society field trip, I discovered colonies of *M. grisescens* in two of the eight caves explored by the party.

The first was a large "nursery" colony in an unnamed cave (which the FSS has named "Mud Cave") on the west bank of the Chipola River in the town of Marianna, about 300 yards upstream from the Louisville and Nashville Railroad bridge (T. 4 N., R. 10 W., Sec. 10). Here there were at least 4,000 *M. grisescens* and 11,000 *M. austroriparius*. The two species were in separate but adjacent clusters on the ceiling of a large passage over 100 yards back from the entrance. The sex ratio was predominantly females in both species. Of 80 adult *M. grisescens* sexed, 6 were males, 74 females. Practically all of the females were obviously pregnant. Of seven females dissected, five were pregnant, each containing one embryo with crown-rump lengths of 10, 13, 14, 16, and 17 mm. A few young had already been born, or were born to captive females that evening. Two cases of parturition were observed in the cave. This is about six weeks earlier than the young are born in central Missouri (Guthrie, Jour. Mamm., 14: 204, 1933). The bats were rather heavily infested with *Trichobius major*, a parasitic streblid fly.

The second colony was found in Old Indian Cave (T. 5 N., R. 10 W., Sec. 21) about three miles north of Marianna in the Florida Caverns State Park. Here there were only about 1,500 bats, all in one cluster, of which 600 were *M. grisescens* and 900 were *M. austroriparius;* in addition four *Pipistrellus subflavus* were found singly elsewhere in the cave. Both species of *Myotis* were mixed indiscriminately in the cluster. Males were predominant in both species. Of 63 *M. grisescens* sexed, 44 were males, 19 females. No females were noticeable pregnant; the only female dissected contained no embryos. This segregation of the males and non-breeding females apart from the pregnant females during the early summer is in agreement with Howell's (N. Amer. Fauna 45: 24, 1921) observations in Alabama and Guthrie's (Jour. Mamm., 14: 16, 1933) in Missouri. James B. Work, Superintendent of Florida Caverns State Park, says that "during the cold winter weather the entire ceiling of one room in this old cave is covered with large clusters of Brown Bats—numbering probably 15,000. However during the summer the number drops off sharply and only a few hundred remain" (*in litt.*, April 8, 1954). It remains to be determined whether these are *M. grisescens* or *M. austroriparius*, and from where they come. An increase in numbers during the winter is certainly contrary to my experiences with *M. austroriparius* in peninsular Florida; on the other hand, *M. grisescens* is migratory in parts of its range (Guthrie, *loc. cit.*), although a permanent resident elsewhere (Howell, *op cit.*: 23). It could be that this increase is due to an influx of *M. grisescens* from farther north.

The next nearest locality to the Marianna region from which *M. grisescens* has been recorded is 200 miles to the north at Anniston, Calhoun County, Alabama (Miller and Allen, U. S. Nat. Mus. Bul., 144: 83, 1928). The karst region of the Marianna Hills is isolated from that area by 115 miles of caveless coastal plain. Since caves are apparently a requirement for this species, the Marianna population is probably isolated from those to the north.

On comparison of Marianna specimens with topotypes from Nickajack Cave, Marion

County, Tennessee, in the collection of H. B. Sherman; and with the measurements given by Miller and Allen (*op. cit.*: 84), no differences of racial magnitude were apparent. All of the specimens are in the so-called "russet" color phase. Twelve skins and skulls (Nos. DWR 510, 511, 524, 526; DBUF 984–991) and sixteen alcoholic specimens (Nos. DBUF 992-1007) are in my collection and the University of Florida Department of Biology collection.

I wish to thank Dr. H. B. Sherman for the loan of the specimens from Nickajack Cave, Tennessee.—Dale W. Rice, *Department of Biology, University of Florida, Gainesville.* *Received August 29, 1954.*

THE LEAFCHIN BAT IN ARIZONA

The leafchin bat, *Mormoops* (= *Aello*) *megalophylla* (Peters), has been reported from only three localities in the United States, all in Texas. These are: Ft. Clark, Kinney Co., 1 (Rehn, Proc. Acad. Nat. Sci. Philadelphia, 54: 169, 1902); Edinburg, Hidalgo Co., 3 (Muliak, Jour. Mamm., 24: 269, 1943); Frio Cavern, Uvalde Co., "many" (Mohr, Bul. Nat. Speleological Soc., 10: 105, 1948).

Recently two females of this species were taken in a net over a waterhole in the Santa Rita Mountains, 5 mi. N, 2 mi. W of Patagonia, Santa Cruz Co., Arizona. One, taken in the night of June 10, 1954, contained one embryo. The second, taken the following night, was non-gravid. The waterhole is located in a riparian community of mature cottonwood, sycamore and willow, at an elevation of 4450 feet, in the oak woodland.

Also taken at the same time and location were: *Tadarida mexicana*, *Myotis evotis*, *Eptesicus fuscus*, *Antrozous pallidus*, and *Lasiurus borealis*. The two *Mormoops megalophylla* are now specimens (skins and skulls of the adults, the embryo in alcohol) in the collection of the Zoology Department at the University of Arizona.

In the western part of its known range, the northernmost location previously reported is "fifteen miles northeast of Guaymas, Sonora, Mexico" (Burt, Univ. Michigan Mus. Zool. Miscl. Publ. No. 39, 1938). Therefore, this first record for Arizona represents a considerable northern extension of the known range.—Lee D. Beatty, *Department of Zoology, University of Arizona, Tucson.* *Received July 26, 1954.*

BUTTERFLIES AND A KITTEN

The note by Morris (Jour. Mamm., 34: 510–511, 1953) was recalled on June 18, 1954, by seeing a large number of our common swallowtail butterflies taking water on the beach of Baptiste Lake, Hastings Co., Ontario. My attention was attracted by some detached wings of the swallowtails along the shore and I immediately thought of chipmunks. However, they were not responsible. A kitten, *Felis domestica*, had been brought to the resort and it had found the butterflies easy prey. It would creep up close to a flock, pounce, and usually catch one of the big insects. This it would eat, discarding the wings as it came to them. Probably it had been feeding on the butterflies for several days. I saw the swallowtails first on June 10. By July 2 the flocks had disappeared and the kitten was on other food.—G. C. Toner, *Bancroft, Ontario, Canada.* *Received August 14, 1954.*

REMARKABLE AGE ATTAINED BY A BOBCAT

The American Museum of Natural History has recently received a male bobcat (*Lynx rufus rufus*) which is of interest on account of its longevity.

In the fall of 1928, Mr. Ralph Space of Beemerville, N. J., caught a pair of these cats at High Point, Sussex Co., New Jersey. Mr. Space is a successful fur farmer and has a small private zoo. He installed these bobcats in the zoo and they produced three or four litters which he raised. The female cat died in 1950. The male, a remarkably fine specimen, died in March, 1953. At the time of his death he showed signs of aging and was not in perfect physical condition, but in spite of this he weighed 30½ lbs. when he was received at the museum.

At the time of their capture, both of these cats were adults, which would lead one to believe that the male cat was over 25 years old at the time of his death. This bobcat is now No. 164480 in the Museum's collection.—T. Donald Carter, *The American Museum of Natural History, New York 24, New York.* *Received March 26, 1954.*

FOOD HABITS OF THE NEWFOUNDLAND RED FOX

The Newfoundland red fox (*Vulpes fulva deletrix*) is increasing rapidly. High populations exist in many parts of the Island, but the low price of the fur prevents heavy trapping pressure. Because of the rapid increase in fox numbers and the fact that prey animals are not plentiful, a collection of fifty scats was made during the course of a summer's moose study in 1953. The scats were collected approximately 15 miles south and east of Badger. The area included sections burned in 1943, 1950 and a portion burned during both fires. A few scats were obtained from the bordering cutover.

No reptiles or amphibians exist in central Newfoundland. In the collecting area, varying hare (*Lepus americanus struthopus*) and muskrat (*Ondatra obscura*) were present. Ptarmigan (*Lagopus lagopus allenî*) and meadow vole (*Microtus pennsylvanicus terranova*) were either rare or absent from the immediate area. Nesting waterfowl and song birds presented the only other possible sources of fresh animal food.

The presence of moose (*Alces alces*) kills in the area from the previous hunting season provided considerable carrion for both fox and lynx (*Lynx subsolanus*). Four scats identified as lynx by odor and size contained bird remains, moose hair and blueberries (*Vaccinium* sp.).

Seven winter scats are included in the analysis presented in Table 1. All contained nearly 100 per cent varying hare. Although volume was not determined accurately, varying hare occurred in great quantities, followed by blueberries in the summer scats. Collecting dates were from June 23 until August 22, 1953.—Donald G. Dodds, *Department of Conservation, Cornell University, Ithaca, N. Y.* *Received August, 1954.*

Table 1.—*Food of the red fox in north central Newfoundland based on 43 summer and seven winter scats*

Foods	Frequency	Per cent occurrence
Animal		
Varying hare (Includes 7 winter)	28	56
Unidentified birds	18	36
Beetles	12	24
Moose	7	14
Unidentified vibrissae and hair	4	8
Egg shells	1	2
Flies (Diptera)	1	2
Meadow voles	1	2
Muskrat	1	2
Plant		
Balsam (*Abies balsamea*) leaves	16	32
Blueberry	14	28
Raspberry (*Rubus* sp.)	11	22
Gramineae & Cyperaceae	6	12
Unidentified seeds	6	12
Cranberry (*Vaccinium macrocarpon*)	3	6
Bake apple (*Rubus chamaemorus*)	2	4
Unidentified moss	2	4
Birch (*Betula papyrifera*) seeds	1	2
Detritus		
Mud	2	4
Pebbles	2	4
Wood chips	1	2
Piece of leather	1	2

RECORDS OF THE NEW-MEXICAN BRIDLED WEASEL IN KANSAS

The range of the New-Mexican bridled weasel, *Mustela frenata neomexicana* (Barber and Cockerell) in Kansas is uncertain. Cockrum (MAMMALS OF KANSAS, 1952: 248) lists its distribution as, "probably the southwestern part of the state, known only from one specimen from Seward County."

I first encountered this animal about one mile west of Feterita, Stevens County, Section 30, Township 33S, and Range 39W, on June 4, 1952 when I salvaged a specimen from highway 45 and 51. It had apparently been run over by a dual wheeled truck, as the skull and hindquarters were badly crushed.

On November 10, 1953, during the pheasant season, I received a telephone call from Preston Osborne of Lakin, Kansas, saying a hunter friend of his, Mr. Dorsch of Kansas City, had shot what he thought to be a rabbit in the weeds, but found he had shot into a family of what they thought were young mink, *Mustela vison letifera* (Hollister). I drove to Lakin and found these animals to be New-Mexican bridled weasels. According to Mr. Osborn, there were two adults and four young in the family. Two of the young had been killed and another wounded, which died three days later. The location of the family had been along the southeast shore of Lake McKinney, Section 7, Township 24S, Range 35W. Two of the specimens were made into life mounts, one returned to Mr. Osborne, the other retained by me. The third was given to Dr. Claude W. Hibbard of the University of Michigan and is U. M. M. Z. No. 1137, in their collection.

In addition to the above records, Dr. Hibbard tells me that during the summer of 1953, he took from a great horned owl pellet, on Section 25, Township 34S, Range 31W, XI Ranch, Seward County Kansas, a complete skull and a few isolated bones of this animal.—MARVIN D. SCHWILLING, *Game Biologist, Kansas Forestry, Fish, and Game Commission, Box 864, Garden City.* *Received May 26, 1954.*

OBSERVATIONS ON THE RING-TAILED CAT

The recent article by Taylor (Jour. Mamm., 35: 55–63, 1954) on the ring-tailed cat stimulated these additional remarks. In the fall of 1944, while I was on duty with the USAAF at San Angelo, Texas, my wife and I were presented with a young female *Bassariscus astutus*. It had been captured for me by a game warden somewhere southwest of San Angelo. He informed me that he obtained it from a nest in a rock wall, and that they were easy to locate in such places since the young ringtails could be heard voicing annoyance when one passed by.

Our *Bassariscus* never became fully tame, probably in part because we kept it caged much of the time. It enjoyed running about on the sun porch and climbing on the screens when allowed the freedom of the house. It made no serious efforts that we could see to get outside. Picking it up was somewhat of a problem as our pet did not like to be handled and would struggle and squirm vigorously to be free. Fortunately it never made any serious attempt to bite. It was most convenient to pick it up by the tail, an action to which it did not usually object. If it did resent being so handled, instead of struggling, a strong odor reminiscent of weasel was emitted.

Following my release from active duty, we brought our ringtail home with us to Hamilton, New York. It was allowed considerably more freedom here, and eventually got outside during severe weather in January, 1947. No trace could be found of our pet for several weeks thereafter. The house in Hamilton had six very large and old Norway spruce about it. These trees, and those of the neighborhood generally, supported a large population of red squirrels. Several times in the weeks following the escape, I found red squirrel remains under these spruce trees, usually the remains consisted of entire tails, feet, and pieces of skin and fur. Returning home late one night during a snow storm, my wife and I were amazed to see our *Bassariscus* revealed by the car headlights on a low limb of one of the spruces, with a small mammal in its mouth. It quickly disappeared up the tree. At the base of the tree was the tail of a red squirrel. There were no tracks in the snow nor did we ever find any tracks of

the escapee. A careful scrutiny of the spruce trees the next morning did not disclose the ringtail. Its hiding place was eventually revealed a week or so later when one of our neighbors saw a strange animal in her wood shed. The ringtail was soon captured beneath a stack of shutters where it had apparently lived most of the time during its month of freedom. There was no nest, but the feet, wings and feathers of more than a dozen starlings were scattered about under the shutters.

Our pet returned to the routine of the household no less tame than before. It escaped a second and final time the following summer at Gloucester, Massachusetts, when a visitor opened the cage door to give it some water and then forgot to lock the door again. As before, it did not leave the neighborhood, taking up lodging under the house, which was right on the sea shore. Although no evidence of its food habits were observed this time, presumably its diet could have included *Microtus*, *Peromyscus*, and *Sylvilagus*, all of which were abundant in the immediate neighborhood. It may also have foraged along the strand line where more than one mink seemed to find sufficient sustenance. It lived through the winter of 1947–48, which was notably severe here. Tracks were last seen in May of 1948. Whether it finally died (it was then four years old) or moved to some new locality has remained a question.

Our *Bassariscus* ate any meat put before it and occasional bits of cooked carrot and other vegetables. It was so fond of chocolates that it would risk being handled to get them. The ability of this mammal to survive during severe winter conditions in both central New York and along the Massachusetts shore suggests that it might do very well in the northeast. Ecologically, it appears to be adapted at least in part to the niche occupied by the marten, that of an arboreal, squirrel and bird predator. It would probably be well to avoid the possibility of introduction. Our pet was certainly capable of taking care of itself to the detriment of red squirrels and starlings.—Robert L. Edwards, *Ardea, McClellanville, South Carolina. Received May 3, 1954.*

DICHROMATISM IN MICHIGAN RODENTS

Specimens exhibiting albinistic tendencies, partial or complete, are not uncommon in most groups of mammals, and have been reported for nearly all families of rodents. To my knowledge, however, there is no published account of albinism in the bog lemming, *Synaptomys cooperi cooperi* Baird, a situation perhaps reflecting the relative scarcity of this form in collections. A completely albino specimen, a male captured by a domestic cat, was retrieved on November 11, 1953, at the Rose Lake Wildlife Experiment Station, Clinton County, Michigan. Its measurements were as follows: total length 120, tail 21, hind foot 19, ear from notch 10 mm. The pelage was completely white, above and below, and of an unusually soft texture. The individual hairs were uniformly white from base to tip, and no color except that due to the blood was apparent in the skin. The eyes, of a pink hue, also lacked pigment. The specimen is preserved in the collection of the Zoology Department, Michigan State College. I am grateful to C. T. Black for bringing it to my attention.

In another connection, it seems worthwhile to report a melanistic gray squirrel, *Sciurus carolinensis leucotis* Gapper, observed near Moddersville in Missaukee County, Michigan, on November 14, 1953. This squirrel seems to agree closely with the one from Minnesota described in detail by Breckenridge (Jour. Mamm., 28: 403–404, 1947). It was completely black throughout except for a conspicuous white tip to the tail. The observers, R. C. Ball and T. W. Porter, reported that the tail was noticeably shorter than normal. This specimen was not collected.—Richard H. Manville, *Michigan State College, East Lansing. Received April 21, 1954.*

WEIGHTS OF ADULT GRAY SQUIRRELS

Checking stations on West Virginia's state-owned forests offered technicians the opportunity to weigh 10,973 gray squirrels, *Sciurus carolinensis* Gmelin, during the October hunting seasons of 1949 through 1952. A total of 4050 squirrels were classified as adults and these are discussed in this paper. Age classifications were based on the examination of sexual organs as outlined by Allen (1943). Squirrel weights were obtained from specimens

TABLE 1.—*Weights of 4050 adult gray squirrels from West Virginia, 1949–1952*

Map No.	State Forest	Elevation Range (feet)	Latitude	Sample Size		Average Weight	
				Males	Females	Males	Females
1	Seneca	2360–3650	38° 15′	423	461	559	551
2	Greenbrier	1800–3360	37° 45′	61	61	538	538
3	Panther	1200–2100	37° 25′	31	33	538	523
4	Cooper's Rock	700–2300	39° 37′	396	334	528	514
5	Elk River Refuge	900–1650	38° 40′	335	398	514	515
6	Kanawha	750–1350	38° 20′	470	464	500	500
7	Cabwaylingo	700–1350	37° 50′	220	363	502	502
Totals				1936	2114	523	518

TABLE 2.—*Weights of adult gray squirrels of Eastern United States*

State	Season	Location or Approximate Latitude	Sample Size		Total	Average Weight		Source of Information
			Males	Females		Male	Female	
Mich.	Year round	Swan Creek	34	29	63	558	560	D. H. Jenkins, 1953
Penn.	Year round	Wildl. Exp. Sta. State College, Centre County	6	3	9	576	562	Vagn F. Flyger, 1952
Md.	Year round	3–5 miles north Solomons, Calvert County	13	14	27	546	542	Vagn F. Flyger, 1952
Ohio	Sept.–Oct.	Nile Township, Scioto County	—	—	994	518	521	F. Chapman, 1941
Ind.	Sept.–Oct.	95% examined on Morgan-Monroe State Forest	100	109	209	528	530	J. M. Allen, 1952
Ill.	Year round	State-wide 37°–42°	102	107	209	535	535	L. G. Brown and L. E. Yeager, 1945
Va.	Oct.–Dec.	Blacksburg	28	24	52	513	513	H. S. Mosby, 1953
Ky.	Apr.–Nov.	Coburg, Adair County	75	148	223	464	473	E. C. Bertram, 1952
N. C.	Oct. Year round	State-wide 35°–37°	—	—	34 90		520 509	T. S. Critcher, 1953
Ala.	Oct.	State-wide 31°–35°	385	316	701	488	485	Wayne F. Colin, 1953
Miss.	Year round	Pascagoula River Drainage Area	221	241	462	458	462	H. R. Redman, 1953
Fla. & Ga.	—	— 25°–31°	—	—	10	400–450		W. J. Hamilton, Jr., 1943

brought into the checking stations by hunters. Multilated and gutted squirrels were eliminated from the sample.

The state-wide sample indicated little difference between the sexes; the males averaged 523 grams and the females 518 grams (Table 1). The results indicated that squirrels from the higher elevations of the Allegheny Mountains in the eastern part of the State were heavier than those taken in the southwestern section where lower elevations prevail (Table 1). It appears that this difference in weight is due to the presence of two subspecies, *S. c. carolinensis* and *S. c. leucotis*, in the State. Both are listed as present in West Virginia by Kellogg (1937).

The heavier specimens along the Allegheny as represented by those taken on Seneca State Forest are more typical of *S. c. leucotis* of the northeastern United States, while those from Kanawha and Cabwaylingo approach *S. c. carolinensis* of the southeastern United States, in weight. Kellogg (*op. cit.*) pointed out that while the squirrels in the southwestern part of West Virginia approach *S. c. carolinensis* in size they are nearer *S. c. leucotis* in color. The squirrels taken on the other forests of the State would appear to represent intergrading populations as far as weight is concerned.

Weight data on gray squirrels collected in other states (Table 2) indicates a north-south cline in average weight, with greater weights prevailing in the north and lesser weights in the south. However, the weight gradient appears to be steeper in the area of intergradation between the subspecies *S. c. carolinensis* and *S. c. leucotis*, than it does between other localities within the geographic ranges of these subspecies. For example, the difference between average weights in Alabama (487 grams) and southwestern West Virginia (500 grams), a distance of approximately 400 miles, is only 13 grams; while the weight difference between Cabwaylingo and Seneca State Forests in West Virginia, a distance of only 120 miles, is 55 grams. It appears that weight, as well as coloration and lineal dimensions could be useful in subspecific determinations of gray squirrels.

On the basis of weight, it appears that the samples from Illinois, Morgan and Monroe State Forest in Indiana, Scioto County in Ohio, Blacksburg, Virginia and those collected in Maryland and North Carolina represent intergradations between the subspecies *S. c. carolinensis* and *S. c. leucotis*.

The writer is indebted to Conservation Departments and individuals who so willingly provided the squirrel weights collected in their respective states. He wishes to thank all the game technicians in West Virginia who aided in collecting the data. Special thanks goes to Mr. Charles O. Handley, Sr. and Charles O. Handley, Jr. for their review of the manuscript. This paper is a contribution of West Virginia Federal Aid Project 31-R.

LITERATURE CITED

ALLEN, D. L. 1943. Michigan fox squirrel management. Michigan Dept. Conserv., Game Div. Pub. 100. Lansing.

ALLEN, J. M. 1952. Gray and fox squirrel management in Indiana. Indiana Dept. Conserv. Indianapolis.

BERTRAM, E. C. 1952. Kentucky squirrel investigations—A three year report. Kentucky Dept. Fish and Wildlife Resources. Frankfort.

BROWN, L. G. AND L. E. YEAGER. 1945. Fox squirrels and gray squirrels in Illinois. Illinois Nat. Hist. Surv. Urbana.

CHAPMAN, F. B. 1941. The 1940 squirrel harvest on ten public hunting preserves in Ohio. Release No. 162. Ohio Res. Sta. Ohio State Univ. Columbus.

COLIN, W. F. 1953. Department of Conservation. Monroeville, Alabama. Personal correspondence.

CRITCHER, T. S. 1953. Wildlife Resource Commission. Raleigh, North Carolina. Personal correspondence.

FLYGER, V. F. 1952. A study of the nest box habits and the breeding season of the gray squirrel (*Sciurus carolinensis leucotis*) in Maryland and Pennsylvania. Unpub-

lished manuscript. Dept. Zool. and Ent. Pennsylvania State Coll. State College, Pennsylvania.

JENKINS, J. H. 1953. Michigan Department of Conservation. Lansing. Personal correspondence.

HAMILTON, W. J., JR. 1943. The mammals of Eastern United States. Comstock Publishing Company. Ithaca, New York.

KELLOGG, R. 1937. Annotated list of West Virginia mammals. Proc. U. S. Nat. Mus., 84: 443–479.

MOSBY, H. S. 1953. Virginia Cooperative Wildlife Research Unit, Blacksburg, Virginia. Personal correspondence.

REDMAN, R. H. 1953. Analysis of gray squirrel breeding studies and their relation to hunting seasons, gunning pressure and habitat conditions. Trans. 18th N. A. Wildlife Conf.: 378–389.

HANS G. UHLIG, *Seneca State Forest, Dunmore, West Virginia.* *Received May 27, 1954.*

GRAY SQUIRRELS FEEDING UPON SAMARAS OF ELM

During the last two weeks of June, 1954, an assemblage of squirrels, *Sciurus carolinensis* Gmelin, occurred on the lawn on warm days beneath two American elms standing about twenty yards apart on the campus of the University of Western Ontario, London, Ontario. Anywhere from three to ten squirrels, some gray and some black, were commonly present at any one time. When unmolested they remained quietly in the area and were busily engaged in feeding, sometimes nuzzling along the ground and sometimes picking up small flat objects from the ground with their fore paws and nibbling away at them. When the squirrels were approached cautiously it was seen that they were feeding on the newly-fallen samaras of the elms which littered the ground in thousands beneath the two trees. The flattened samaras of *Ulmus americana* are slightly more than 1 cm. long, ciliated around their borders and notched at their tips, and each encases a flat seed slightly less than 0.5 cm. long. Examination of samaras dropped by the squirrels disclosed that the investing sheath of one side of each samara had been torn open and the seed extracted. This was accomplished by the squirrel holding the samara in its fore paws and opening it with its teeth, whereupon the empty husk was dropped to the ground. On June 29 one squirrel, sitting on its haunches, was observed at close quarters and over a period of five minutes it picked up samaras, extracted the seeds and discarded the husks at the rate of about ten per minute. In a handful of samaras, scraped from the ground where they were most plentifully distributed beneath the trees, about half the samaras were found torn and devoid of their seeds.—W. W. JUDD, *Department of Zoology, University of Western Ontario, London, Canada.* *Received July 7, 1954.*

NOTES ON THE THIRTEEN-LINED GROUND SQUIRREL IN UTAH

The population and distribution status of the thirteen-lined ground squirrel, *Citellus tridecemlineatus parvus*, in Utah appear to be rather uncertain. Durrant (Univ. of Kansas Publ., Mus. Nat. Hist., 6: 116, 1952) listed only thirteen records of specimens collected in the state. Kelson (Univ. of Utah, Biol. Series, 11(3): 27, 1951) and Durrant (*op. cit.*) indicated that the status of these squirrels may be rare. They stated that several mammalogists, making special trips into eastern Utah, had been unsuccessful in collecting a single specimen. In view of the fact that added collections and observations have been made, it is felt that publication of this data would be worth while.

The unpublished collection records follow. *Duchesne County:* 1 ♀, 1 ♂, seven miles southwest of Myton, June 4 and 5, 1953, by C. L. Hayward, B.Y.U. collection; 2 ♀, 2 ♂, five miles west of Roosevelt, April 17, 18, and May 26, 1953, by Merlin L. Killpack, B.Y.U. collection. *Uintah County:* 1 ♂, one half mile west of Ft. Duchesne, March 28, 1954, by Merlin L. Killpack, private collection; 1 ♀, four miles northwest of Ft. Duchesne, April 2, 1954, by Merlin L. Killpack, private collection; 1 (sex unknown), on west edge of Ashley Valley about 2 miles west of Vernal, September 1951, by A. D. Lewis, Vernal Field Museum of Natural History collection.

Another specimen was captured alive on the Roosevelt Junior High School grounds in September, 1951, by Don N. Crittenden. It escaped after two weeks in captivity. Leo Thorne, Vernal, Utah, informed me that he saw two cross the highway one mile east of Gusher, Uintah County. Some of the people engaged in farming, near Roosevelt, reported that three or four years ago they saw a number of these little squirrels in their grain and corn fields. One of them stated that years ago they were quite numerous on his ranch at the mouth of Antelope Canyon, Duchesne County. It is of interest to note also that years ago those engaged in farming considered these little squirrels a special problem. They claimed that they had to plant their corn as many as three times a season as these squirrels seemed to know where each hill had been planted, hence the local name "Corn Weasel".

These squirrels do not seem to be confined to any one special habitat. Those collected by the writer were captured on the edge of cultivated fields, living on sandy knolls, in small ledges, or occupying old burrows of the kangaroo Rat, *Dipodomys ordii*. In fact the first specimen caught was captured in a pocket gopher trap set in what appeared to be an old burrow of a pocket gopher, *Thomomys sp.*, but later proved to be the burrow of a kangaroo rat. The two specimens taken by Dr. Hayward were captured in shadscale, *Atroplex sp.*, three miles from the nearest farm. Mr. Lewis shot the specimen he collected in sagebrush, *Artemisia tridentata*, near some ledges about one mile from cultivated fields.

Perhaps the small number of individuals observed today is due to the fact that these squirrels are not very gregarious (Howell, N. Amer. Fauna, 56: 18, 1938) and are somewhat secretive in their habits.

One of the squirrels taken west of Roosevelt was captured alive and has been kept in captivity at the Brigham Young University by D. Elden Beck. Dr. Beck informs me that even now, after a year in captivity, this squirrel has not shown any indication of becoming tame.

Perhaps the farmers are not as much aware of these squirrels now since their farming practices have changed somewhat. Possibly the population cycle has been a factor in the number of individuals observed over the years. Ernest Untermann, Director of the Vernal Field Museum of Natural History, says that they see *Citellus tridecemlineatus parvus* occasionally while on their field trips, but he would consider their status as uncommon.

I wish to extend my thanks and appreciation to the following who have helped or contributed information: Dr. C. L. Hayward and Dr. D. Eldon Beck, Brigham Young University; Ernest Untermann, director of Vernal Field Museum; Leland Mecham, Frankie Winn, and Daniel Gardner, students; and the farmers in the Roosevelt area.—MERLIN L. KILLPACK, *Union High School, Roosevelt, Utah.* *Received June 15, 1954.*

LATE FALL HOME RANGES OF THREE GOLDEN MICE, *PEROMYSCUS NUTTALLI*

From October 22 to December 8, 1951, during the course of a small mammal study in Knox County, Tennessee, a condition became apparent in regard to three golden mice (*Peromyscus nuttalli*) that seems worthy of mention.

Part of the study involved home range and population estimates. Livetraps, placed at 25 feet intervals, were used to accumulate data for these estimates. The method employed to calculate the home ranges was that used by Manville (Misc. Publ. Mus. Zool., Univ. Michigan, no. 73: 1-83, 1949). The home ranges drawn for the three golden mice were long but narrow, apparently following a strip of bushes and small trees heavily entwined by Japanese honeysuckle (*Lonicera japonica*). Unfortunately, these ranges touched one or two boundaries of the study area and were considered incomplete although it is believed that assumed extensions out of the area resulted in over-estimations of these ranges (average of .26 acre). Traps set outside the boundaries in question failed to take the three mice and the boundary most touched was a railroad track that seemed to limit the movement of this species. These three individuals were the only golden mice that had the major part of their home ranges within the trapping area.

The three mice, all females, lived in two shelter nests that were approximately 20 feet apart. Paint of different colors put on the tails of the mice served to identify the individuals

as they were chased from the nests. Usually, all three were in one of the nests, but at times they were variously divided in the two nests.

It might have been supposed that these three small mammals, living in apparent amicability in the same shelter nests, would have had greatly overlapping ranges, especially in the vicinity of the nests. However, two of the mice had almost exclusive home ranges. The range of one mouse (no. 7, 30 captures at 18 stations) was, except for the area plotted around a trapping station close to the nests, entirely to the west of the nests. Most of the range of the other mouse (no. 6, 15 captures at 13 stations) was to the east of the nests, but to the northwest and west, it overlapped with the range of no. 7, both mice being trapped at various times at the same three stations. Considering the method used, it was estimated that the overlap area constituted approximately 20 per cent of each individual's home range (both mice had estimated ranges of 11,875 square feet).

Although these ranges might be suggestive of feeding territoriality, the home range of the third mouse (no. 1, 18 captures at 14 stations) would seem to somewhat negate this suggestion. This mouse ranged freely into the ranges of the other two individuals and the shelter nests were located near the center of its range, rather than at the sides (or more exactly—ends), which was the situation in the case of the other two mice. Possibly the almost exclusive ranges of the golden mice numbered 6 and 7 may have indicated a preference for, or familiarity with, the areas in question.—PAUL B. DUNAWAY, *U. S. Fish Cultural Station, Fish and Wildlife Service, Orangeburg, South Carolina.* *Received May 17, 1954.*

THE RICE RAT, *ORYZOMYS PALUSTRIS TEXENSIS*, IN NORTHWESTERN ARKANSAS

On February 3, 1954, the writers took five specimens of the rice rat, *Oryzomys palustris texensis*, eight miles east-northeast of Siloam Springs, Benton County, Arkansas. This is more than 110 miles north of Rocky, Polk County, Arkansas, which is the nearest locality where this animal was previously known to occur.

There reportedly is a mounted specimen of a rice rat in the United States National Museum taken by B. F. Goss in January, 1859, and labeled Neosho Falls, Woodson County, Kansas. However, the validity of this record is in doubt. Cockrum (MAMMALS OF KANSAS, 1952: 281), after discussing the circumstances under which the specimen was taken, says that he is inclined to believe that there is an error in the locality and refers *Oryzomys palustris* to the hypothetical list for the state of Kansas. An additional specimen of Goss' at the Museum of Comparative Zoology, Harvard University, is supposed to have come from the same locality, but all original data are lacking. In view of this, it is worthy of note that our specimens represent an extension of the known range of the species to within sixty miles of the state of Kansas.

Our rice rats were taken from well-worn runways in the grass bordering the artificial minnow ponds near Osage Creek, a tributary of the Arkansas River, and were found in association with *Sigmodon hispidus*, *Peromyscus maniculatus*, *Reithrodontomys fulvescens*, and *Mus musculus*. The specimens are in the University of Illinois Museum of Natural History.—WAYNE H. DAVIS AND WILLIAM Z. LIDICKER, JR., *Museum of Natural History, University of Illinois, Urbana.* *Received April 8, 1954.*

EXTRA TEETH IN THE PYGMY MOUSE, *BAIOMYS MUSCULUS*

The maximum number of cheek teeth in the rodent families Cricetidae and Muridae is normally 12. Instances of a number exceeding 12 are rare but there are several on record (Tokoro, Zool. Mag. Tokyo, 55: 72, 1943; Johnson, Jour. Mamm., 33: 70, 1952). A specimen of *Baiomys musculus* at hand has 14 cheek teeth, four in each maxilla and the normal three in each mandible. This is the first example of a bilateral increase in molariform teeth that I have seen in thousands of specimens of cricetids that I have examined. The specimen, University of Michigan Museum of Zoology number 100239, is one of several trapped in arid tropical vegetation three miles southeast of Colima, Colima, México.

The right and left maxillary tooth rows in this specimen are essentially identical, one a mirror image of the other. The length of the row is normal. The right row, for example, meas-

ures 3.4 mm. compared with 3.3 mm. in specimen number 100240 which was obtained at the same time and place. The four cheek teeth therefore are crowded into the space typically occupied by three. Each of the teeth is slightly shortened to make room for the fourth tooth. The first and second teeth in the row are normal, although slightly shorter than usual. The third is the extra tooth in each maxillary row. It is a smaller replica of the second, but with a reduced anterior cingulum. The fourth tooth, thus, is M^3. It resembles M^2 in other specimens of *Baiomys*. Normally M^3 is oval in occlusal outline. Its rather even contour is broken laterally by a single enamel fold which extends antero-medially more than half way across the tooth. In the present specimen the primary fold is shorter and the tooth is elliptical in occlusal outline. It is as wide as a normal M^2 but its antero-posterior diameter is less, amounting to approximately one-half the breadth of the tooth.

All of the teeth are functional. All show moderate wear. The wear is normal and is bilaterally symmetrical, similar in all four tooth rows. Occlusion of the upper and lower rows is necessarily atypical, but the fact that wear is symmetrical indicates that occlusion is not greatly modified and that the animal was not inconvenienced in chewing. Occlusion is abnormal only in the posterior teeth. The extra M^3 is situated directly above M_3 so that the paracone and metacone face the protoconid and hypoconid. Normally M^3 occludes with M_3; the paracone fits into the major fold (located between the protoconid and the hypoconid). In the present specimen, when the jaw is at rest no tooth opposes M^3. M^3 is situated posterior to M_3. Its anterior face lies about on a plane with the posterior face of M_3, but back and forth movement of the jaw in mastication brings the two teeth to bear on each other.

The present example may lend support to the hypothesis that posterior molars have been lost phylogenetically in murids and cricetids and that the first cheek tooth in each jaw is not a molar but instead is a premolar (Johnson, *loc. cit.*).—Emmet T. Hooper, *University of Michigan Museum of Zoology, Ann Arbor. Received April 22, 1954.*

TERRITORIALITY IN WILD HOUSE MICE, *MUS MUSCULUS* L.

A number of workers have studied the social relationships that develop among caged groups of laboratory mice (reviewed by Scott and Fredericson, Physiol. Zool., 24: 273–309, 1951). Brown (Ecol. Mono., 23: 217–240, 1953) observed fighting among wild mice in the free state and found that social hierarchies were formed in groups confined in small pens. My observations confirm that social hierarchies develop in small colonies under certain conditions, but suggest that fighting tends to disperse the population into spatially distinct breeding areas initially occupied by one male and one or two females, i.e. that it is territorial in function. In certain experimental colonies the social order provides a working model illustrating some of the ideas put forward by Burt (Jour. Mamm., 24: 346–352, 1943).

One such group consisted of 28 mice of each sex confined in a 250 sq. ft. enclosure provided with 14 wooden nest-boxes, abundant nesting material, food and water (Fig. 1). The mice were marked by toe-clipping and caught at intervals by surrounding the nest boxes with sheet metal barriers. Table 1 shows the distribution of the mice after four weeks occupancy.

No nests had been built in boxes c, e, g, m and q. Censuses carried out during the next 3 months showed that the individuals remained in the same combinations. (A female left r and moved to b following disturbance by the investigator.)

Watching revealed that the males living in d, f, h, k, n, p, and r attacked and drove away mice intruding into the nest box or an area around it. After several weeks of observation it was possible to identify these males visually, and the outcome of fights in which they were involved could then be recorded (Table 2). The correlation between success in fighting and locality suggests that the areas defended may be regarded as territories.

Each territorial male spent most of its time within its own territory and frequently a tentative investigation of another area was terminated after a sniff at the threshold of the male's nest box. The territory boundaries shown in Figure 1 were determined by observing the positions at which (1) the presence of a mouse elicited attack, (2) a chase was broken off by the attacker, (3) a retreating mouse turned, reared up, and drove its attacker away, and (4) patrolling and "sentry" activity were seen.

(1) Within the nest intruders are doubtless detected by scent, but outside, rushes and

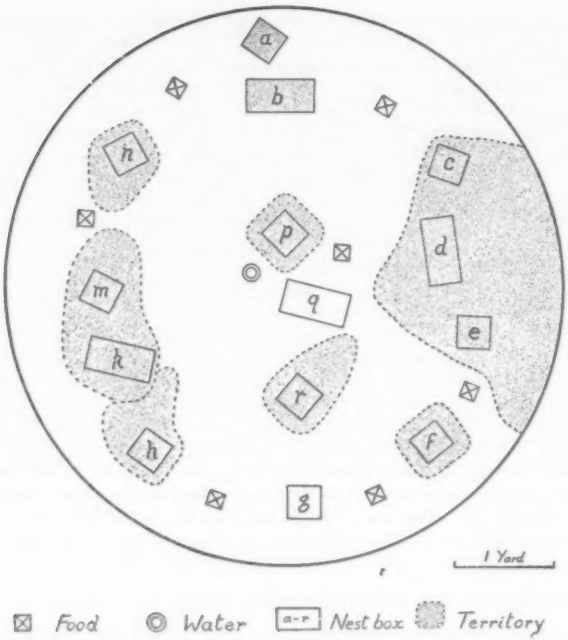


FIG. 1.—Plan of enclosure containing 56 mice.

TABLE 1.—*Distribution of 56 mice in 14 nest boxes*

Box	a	b	c	d	e	f	g	h	k	m	n	p	q	r
No. males	8	13	0	1	0	1	0	1	1	0	1	1	0	1
No. females	0	19	0	2	0	1	0	1	1	0	1	1	0	2
Total	8	32	0	3	0	2	0	2	2	0	2	2	0	3

TABLE 2.—*Fighting success of males*

Mouse No.	Box	In Preferred Area		Elsewhere	
		Won	Lost	Won	Lost
13	h	1	0	0	6
15	f	3	0	0	1
17	p	2	0	0	2
19	k	7	0	0	3
31	d	17	0	0	0
41	r	9	0	0	1
49	n	10	0	0	2

springs of up to 2 feet seem to be directed by sight. Sounds made by an intruder have also been seen to direct the attack of a previously alerted resident.

(2) and (3) Mice always ran from frontal attacks but pursuit was abandoned at a certain distance from the attacker's nest box. Chases sometimes carried an attacker a short distance beyond its own territory, but if it entered the territory of the retreating mouse, the latter turned and drove it back. Sometimes the two mice then sat regarding one another across a narrow neutral zone.

(4) Patrolling activity, aptly called "going the rounds" by Brown (*loc. cit.*) usually followed ejection of an intruder, but "sentry" activity often took place without any apparent external stimulus. Male No. 31, which occupied the largest territory, was exceptionally active both in patrolling and keeping watch. It habitually sat upon the roof of d, peering about and sniffing, and when a mouse entered the territory, hurled itself through the air in a violent attack.

A social hierarchy evidently existed among the males in b. Fighting within this box caused subordinates to leave and wander about the enclosure, and trespassing by these animals provoked 34 of the 49 fights shown in Table 2. Box a was inhabited only by males in poor condition, and the permanent absence of females from this box was probably connected with their low social status. They were, nevertheless, safe from attack within their own box.

A similar social order was formed in four other colonies kept under the same conditions of crowding and cover supply; in each, territories occupied by breeding pairs were formed as well as "reservoir" groups of subordinate animals.

This brief account is given because of the paucity of records of territorial fighting in small mammals. Much work remains to be done before the mechanisms and consequences of territory formation in mice can be fully understood.—PETER CROWCROFT, *Ministry of Agriculture & Fisheries, Infestation Control Division, Surbiton, Surrey, England.* *Received July 30, 1954.*

REPEATED HIBERNATION IN A CAPTIVE MEADOW JUMPING MOUSE

Some observations have been recorded on hibernation of meadow jumping mice (*Zapus hudsonius*) and on their activity during emergence from a torpid state. (Eadie, Jour. Mamm., 30: 307, 1949; Nicholson, *ibid.*, 18: 103, 1933.; Schwartz, *ibid.*, 32: 227–228, 1951.; and Sheldon, *ibid.*, 19: 324–332, 1938.). The following case seems worth recording because the mouse passed repeatedly from a torpid state to active condition within a few days' time.

On the morning of May 15, 1954, an active female jumping mouse was brought into my room by Donald Thomson. It had been taken about one and one-half miles east of Ann Arbor, Michigan, in an open pasture fifty feet from a small stream. Her left foreleg was slightly injured in the trap and her left eye was sealed closed.

The mouse remained active for two days in a covered cardboard box. Water, peanut butter, and dry bread were available. On the morning of May 17, two days after capture, the mouse was in a characteristic hibernation position. After being handled for fifteen minutes, she moved her legs weakly and showed slight breathing motions, but did not become active. That evening, after more attempts at stimulating her into activity, her rate of breathing increased. Within an hour she was running slowly about the box.

The next morning, May 18, she was again in a deep sleep. Temperature of the room was 57.5°F. I counted between 18 and 26 breaths per minute, coming irregularly with three or four in rapid succession, followed by a pause. By early evening of the same day the mouse became active. She was active until 8 or 9 PM on May 19, when she became drowsy. The following morning, May 20, she was in torpor again. A pin prick in her tail brought forth almost immediate vigorous body movements which lasted only momentarily. That evening, upon handling, she became active. Her breathing rate increased considerably, rapid shaking and shivering occurred in the forepart of her body and an occasional deep heave convulsed her whole body. After five to eight minutes of this, she attempted to stand, but was unable to maintain an upright position. The breathing rate was now too fast to count (estimated

over 90 per half second). Fifteen minutes from when she first started shivering, her equilibrium was nearly regained, her uninjured eye was slightly opened, and her nose twitched actively. Within a half hour she was eating peanut butter, but paid no attention to water placed before her. Soon she was jumping around the room, fully active, forty minutes after having been in a torpid state. One hour after this the mouse was in a sleeping position in her box. She woke up immediately when touched, indicating that she was not in torpor.

By the next morning, May 21, she was in deep sleep again. That evening, six days from time of capture, after having passed in and out of a state of torpidity four times, she died.—Gari C. Clough, *Museum of Zoology, University of Michigan, Ann Arbor.* *Received August 14, 1954.*

NOTES ON CHINCHILLA LIBERATIONS IN CALIFORNIA

Two separate chinchilla (*Chinchilla* sp.) liberations have been made recently in California. One release occurred in Los Angeles County during August, 1952, (Baker, letter, 1954) and the other liberation was made in Humboldt County in September, 1952.

The first liberation of chinchillas in California was in the Whittier Hills near Los Angeles, where four pregnant females and eight males were turned loose into the wild. These animals were liberated after having been discarded as culls from a chinchilla rancher's breeding stock. Previous to this release, the California Department of Fish and Game and the U.S. Department of Agriculture jointly determined that these animals would do no harm and thereby gave their permission for the liberation (Seymour, letter, 1954).

Recent contacts with the liberator and the state Department of Fish and Game by the authors give no further knowledge as to the possible survival of this first chinchilla release in Los Angeles County. The liberator stated that he thought he saw one of the animals in the area nine months later; however, his final opinion was that the chinchillas had less than an even chance for survival because of climatic factors.

The second known chinchilla release in California was made in an area centered in a Douglas fir (*Pseudotsuga taxifolia*) forest located in Humboldt County. The release site is approximately 12 miles southeast of Korbel on the county road to Bald Mountain. The elevation of this site is approximately 4,000 feet and the surrounding terrain is forested mountains. The annual precipitation is approximately 42 inches and there is generally a month or two of snowfall during December and January. Water is usually available throughout the year from nearby springs and streams, and an abundance of grass, forbs, browse plants, and trees supplies an ample amount of food for rodents. The closest area inhabited by man is a ranch about three miles away.

The Humboldt County release was also composed of culled animals from a local chinchilla farm. A total of 14 animals was released which included 13 males and 1 female. The female had a disease of the teeth known to chinchilla ranchers as "slobbers."

Although two of the chinchillas were seen by the liberator two weeks after the plant (September, 1952) none have been observed by the writers. A nearby rancher informed the liberator that he saw one chinchilla approximately three miles from the point of liberation one year after the release, but the validity of this sight record could not be checked.

Many predators are in this area such as gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), weasel (*Mustela frenata*), bobcat (*Lynx rufus*), cougar (*Felis concolor*), great horned owl (*Bubo virginianus*), accipiter hawks, Pacific rattlesnake (*Crotalus oregonus*), king snake (*Ophibolus zonatus*), *et al.* Snakes are known to be predators of immature chinchillas according to George (letter, 1954). Ecological and climatic conditions undoubtedly were not suitable and determined the fate of these animals more than any other factor.

In summary, at least two known liberations of chinchillas in California have been made with culled animals from fur farms, and although releases were made in different environments, no known survivals have been recorded.—John C. Voris, James D. Yoakum, and Charles F. Yocum, *Game Management, Humboldt State College, Arcata, California.* *Received June 20, 1954.*

UNUSUAL BREEDING OF COTTONTAILS IN PENNSYLVANIA

In Pennsylvania the usual nesting period for the cottontails *Sylvilagus floridanus* and *S. transitionalis* begins in March and extends through September. Reports of births that occurred immediately preceding or following this period have occasionally been received. Many of these records of late breeding have come from hunters who shot pregnant cottontails during the open hunting season in November. Early breeding is usually unnoticed unless nestling cottontails are found.

In 1952, because of drought conditions, the opening of the small game hunting season was delayed, and a few replacement days of hunting were permitted late in December. On December 27, 1952, a cottontail carrying five embryos in an advanced state of development was shot on the Letterkenny Ordnance Depot in Franklin County. It was estimated that these cottontails would have been born about January 3, 1953. On January 7, 1954, while trapping cottontails for transfer from the above area, a pregnant female was observed. It appeared that parturition would occur about January 17, 1954. These records indicated that some male cottontails are capable of insemination throughout the year, although microscopic studies have not revealed the presence of sperm cells in October, November or December.

Among sportsmen and biologists there has been considerable controversy concerning cottontails producing young during the calendar year of their birth. Pennsylvania studies have indicated that this takes place infrequently—probably during "high" rabbit years only. During 1953, extremely large numbers of cottontails were produced on the Letterkenny Ordnance Depot. Throughout most of Pennsylvania cottontail production was higher than in any of the several previous years, and it was generally concluded that 1953 was a good year for cottontails. During the course of a summer investigation of juvenile mortality, five cottontails of the year were noted to have been pregnant. The earliest observation of such pregnancy was on July 22, 1953, two observations were recorded in August, and two on October 2, 1953. It appears possible that many of the records of late breeding may be the result of young females becoming pregnant as soon as they reach sexual maturity.—GLENN L. BOWERS, *Wildlife Research Division, The Pennsylvania Game Commission, Harrisburg.* *Received June 17, 1954.*

COPROPHAGY IN THE SWAMP RABBIT

It has long been known that the domestic rabbit eats and swallows a proportion of its night droppings, these forming conspicuous pellets in the stomach. Refection, the habit of passing the food twice through the alimentary tract instead of once, is probably more widespread in the lagomorphs than generally recognized (Morat, Rec. Med. Veter. Paris 59: 635, 1881; Madsen, Nature, 143: 981, 1939; Eden, Nature, 145: 36, 1940; Southern, Nature, 145: 262, 1940; and others). That this habit may provide the animal with large amounts of vitamin B produced by bacteria in the food within the large intestine is suggested by Bourlière (NATURAL HISTORY OF MAMMALS, p. 41, 1954).

At 10 AM on March 20, 1954, two miles north of Fort Myers, Lee County, Florida, I shot a swamp rabbit, *Sylvilagus palustris paludicola*. The animal was sitting in a small sunlit glade in a fairly dense copse of shrubs, close by a stream covered with a mat of water hyacinths. These rabbits may often be observed in the small openings among thickets that border dirt roads. Swamp rabbits frequently allow one to approach within a few feet of them as they sun. Individuals often occupy a certain stand during the day for long periods. In time, they may be recognized by specific markings. After preparation of the skin, routine examination of the stomach and the intestine was made. Approximately 60 cc. of food occupied the distended stomach. Its fundus was crammed with more than 200 well formed pale green pellets, varying in diameter from 4.5–8 mm. These pellets were markedly distinct and sharply separated from the macerated matrix and ingesta in the lower part of the stomach. Several nematodes, *Obeliscoides cuniculi*, were recovered from the stomach.

Cursory examination of many stomachs of New York *Sylvilagus floridanus mearnsi* has failed to indicate refection in this cottontail, although it appears reasonable to assume that coprophagy is common to many North American lagomorphs. The time of examination may militate against recovery of these reingested pellets.

While both the swamp rabbit, locally known as the red rabbit, and the cottontail, *Sylvilagus f. floridanus*, occupy the same general range in considerable numbers, the habitat on the mainland is rather sharply defined. Swamp rabbits occupy the wet lower ground and may invade the drier situations favored by the cottontail. To the best of my knowledge, the cottontail does not occupy the damper ground usually chosen by the swamp rabbit. In the late winter and early spring of 1954, swamp rabbits were numerous in those parts of Lee County that I visited. On Estero and Sanibel Islands, these rabbits often sit in a clump of saw palmetto or in the low thickets, conspicuous among the sea oats and other grasses just beyond tide level, on the sand beaches which are modified by the highest tide. When startled from these retreats, the rabbit makes directly for a gopher turtle burrow. A favorite food on Estero Island, where the rabbits are particularly numerous, is the ground cherry, *Physalis ellioti*, the leaves and fruit of which are eaten in some quantity. The ripening reddish fruits of *Opuntia* are also an important part of the food at this season.—W. J. Hamilton, Jr., *Cornell University, Ithaca, N.Y.* *Received June 1, 1954.*

EVIDENCE OF HOME RANGE OF AN ATLANTIC BOTTLENOSE DOLPHIN

An Atlantic bottlenose dolphin, *Tursiops truncatus* (Montague), with a damaged dorsal fin was observed by the author on November 1, 1953, at approximately 0900 at Cedar Key, Florida. The healed injury, the absence of the upper two-thirds of the fin, served as a natural "tag" and permitted ready identification of this individual, even in the brief period of a normal breathing roll. This dolphin was again seen in mid-afternoon on January 24, 1954, and a third time at 1430 on March 20, 1954. The first observation was made in the main ship channel between Atsena Otie and Grassy Keys, approximately 1600 yards SSW of the main pier. On the second observation, the dolphin was again in the main ship channel about 200 yards east of the main pier, and approximately 600 yards WSW of the pier in the same channel on the third sighting. Joining these reference points (Mohr, Amer. Midl. Nat., 37: 233, 1947), an area of some 475,000 square yards is yielded as an estimated minimum home range for this animal at Cedar Key. Further observations would undoubtedly affect this calculation, and may show that the animal is actually restricted to the channel at Cedar Key and does not include some of the shallower flats in its home range, as would be indicated by the theoretical area encompassed by this approximation. On the other hand, it cannot of course be concluded from the small sample that this area actually corresponds to the full home range of this individual.

Dr. Archie Carr and Dr. E. Lowe Pierce, both of the Department of Biology at the University of Florida, state that they recall seeing a similarly injured dolphin at Cedar Key during the past two years, though no definite records were kept. Dr. Carr recalls seeing such an animal in the fall of 1952 and again in the early fall of 1953. Dr. Pierce believes he sighted a similar dolphin in the summer of 1953 and at a similar time in 1952.

The author feels confident that it was the same animal that was observed each time, certainly in the cases of those observations made by him. While there is of course no proof that these records all represent the same individual, there seems little likelihood that such an extensive and characteristic disfigurement would be duplicated coincidentally. If this assumption is correct, then this apparently represents the first definite evidence bearing on the home range of an Atlantic bottlenose dolphin. The observations are insufficient, however, to show whether this animal is a permanent resident of Cedar Key or whether it moves offshore or along the coast and periodically returns to this area. Burt (Jour. Mamm., 24: 351, 1943) has pointed out that an animal may have different home ranges at different seasons or in different geographical areas, and the distance traveled between these home ranges should not be considered as part of the animal's home range. Cedar Key may be only

one of several such isolated home ranges of this dolphin. The dolphin was not observed on the other regular biweekly trips to Cedar Key made by the author over a period of a year in conjunction with an ichthyological study there. A triangular area of some 5.5 square nautical miles was covered on most of these trips, with the author or qualified passengers keeping a lookout.

Though other individuals of the same species were seen in the bay in varying numbers at some time each month, some trips yielded no observations. Thus this species may move in and out of the area for short periods, though it does not seem to be seasonally migratory here. This apparent lack of a seasonal migration in the Gulf of Mexico has been recorded by Gunter (Jour. Mamm., 23: 268, 1942) for *T. truncatus* in Texas, and by Moore (Amer. Midl. Nat., 49: 134, 1953) for this species in the Everglades National Park in southern Florida. The dolphins were usually seen in the channels, the deepest water in the Cedar Key area (not often exceeding 15 feet), though individuals were observed in water only two or three feet in depth.

The author is indebted to Drs. Carr and Pierce for their records, and to Carr for his critical reading of this manscript. Dr. Paul G. Pearson, also of the Biology Department at the University of Florida, and Dr. Joseph C. Moore, Park Biologist, Everglades National Park, have made helpful suggestions.—David K. Caldwell, *Department of Biology, University of Florida, Gainesville.* *Received May 1, 1954.*

THE LIPIDS IN *BISON BISON*

The Arctic and sub-Arctic climates are difficult for any animal to endure. The American bison, which was introduced into central Alaska in the late 1920's, has become adequately adjusted and now thrives.

Although there is an indication that lipids are involved in the adaptation of some mammals to cold, a dearth of "normal" values for the tissue lipids of wild mammals makes it difficult to evaluate the role of fats, in such adaptation, from a wide, comparative point of view. Before any detailed lipid study is possible, it is essential to establish normal lipid values or ranges for the various tissues to be studied. It is the purpose of this report to establish the normal range of lipid values for the various tissues from the Alaskan bison, *Bison bison*.

Field Work.—All tissues were collected on October 1 and 2, 1950. This was during the first two days of the bison hunt ordered for the purpose of thinning out the Big Delta herd to prevent over-grazing. About one gram of tissue was taken from the animal as soon as possible after death by shooting.

The breast muscle used was a section taken from approximately the same region of the left pectoralis major muscle of each animal; the neck muscle, a section from the left sternomastoid muscle; the heart, a section from the tip of the ventricle; and the stomach wall, a section from *abomasum*. All other tissue specimens were taken from the same general region of the respective organs.

The tissue samples were weighed accurately on a torsion balance and placed in an eight dram vial containing sufficient Bloor's mixture (ethanol:benzin, 3:1) to preserve and extract the lipids. One milliliter of the biological fluids (blood and milk) was measured with blood pipets into vials containing Bloor's mixture. The specimens were then packed and transported to St. Louis University for detailed chemical analysis.

According to Pilgrim (1943), "In 1928, 23 buffaloes were brought from the Flathead Reservation in Montana and released in the Big Delta district along the Richardson Highway. These animals quickly adapted themselves to the new country and have increased in number until the herd now (1943) numbers more than three hundred." During the last official count of this herd in April, 1949, 325 animals were found within a 25 mile radius of Big Delta.

Chemical Methods.—Tissues were analyzed for lipids by methods used previously (Wilber and Musacchia, 1950).

Results.—The results of lipid analyses are given in Table 1. It is evident that the amount

TABLE 1.—*Lipids in the tissues from the bison. Note the relatively small standard deviations for most tissues (figures in parentheses)*

Tissue	Number of Individuals	Lipids (per cent)		
		Fatty acids	Phospholipid	Cholesterol
Liver	11	10.33 (1.3)	6.46 (0.6)	0.240 (.02)
Kidney	11	5.98 (0.7)	2.57 (0.6)	0.313 (.03)
Spleen	9	5.62 (0.7)	2.31 (0.3)	0.406 (.04)
Adrenal	10	7.57 (1.8)	2.63 (0.9)	0.322 (.09)
Lung	10	6.38 (1.6)	2.45 (0.8)	0.376 (.10)
Heart	9	6.71 (1.1)	1.95 (0.4)	0.115 (.02)
Breast Muscle	11	3.65 (0.5)	1.00 (0.4)	0.054 (.01)
Neck Muscle	6	4.11 (0.8)	1.09 (0.2)	0.067 (.05)
Stomach Wall	6	5.68 (1.0)	0.87 (0.1)	0.124 (.02)
Testes	7	6.41 (0.4)	2.61 (0.4)	0.259 (.01)
Ovary	2	3.72 (0.6)	1.60 (0.3)	0.207 (.03)
		Lipids (milligrams per 100 ml.)		
Milk	2	6750	900	20
Blood	2	1000	275	122

TABLE 2.—*Lipid ratios for various tissues from the bison*

Tissue	Lipid Ratios		
	$\frac{FA}{P}$	$\frac{C}{FA} \times 100$	$\frac{P}{C}$
Liver	1.59	2.32	26.9
Kidney	2.32	5.23	8.2
Spleen	2.43	7.22	5.7
Adrenal	2.88	4.25	8.2
Lung	2.60	5.89	6.5
Heart	3.44	1.71	16.9
Breast Muscle	3.66	1.46	18.6
Neck Muscle	3.77	1.63	16.2
Stomach Wall	6.52	2.18	7.0
Testes	2.45	4.04	10.1
Ovary	2.32	5.72	7.7
Milk	7.50	0.30	45.0
Blood	3.64	12.20	2.3

of total fatty acids varies from tissue to tissue. The phospholipids are also appreciably variable. On the other hand, cholesterol values do not vary so markedly.

The following phospholipid ratios were calculated and are listed in Table 2: fatty acids/phospholipids, cholesterol/fatty acids x 100, and phospholipid/cholesterol.

Discussion.—The tissues of the bison show a relatively large amount of lipids as compared with closely related domestic species (e.g., cattle) or with other northern mammals. In the liver of the bison there is about 10 per cent total fatty acids; in beef liver, 4 per cent (Bloor, 1943). Moreover, in several Arctic mammals the total fatty acids in per cent fresh tissue are as follows: polar bear, 10; walrus, 4; seal, 5; caribou, 4 (Wilber and Musacchia, 1950). It is know that wild animals of the same species have higher liver lipids than those kept in captivity (Kellogg, 1939). The high lipid values found in the present work for the bison tissues may be explained in part by this fact.

A study of Table 2 reveals several interesting facts concerning the lipids of tissues from the bison. The ratio of phospholipid/cholesterol in the liver gives a value of close to 27. This indicates that in relation to cholesterol, there is a very high concentration of phospholipids in the liver of the bison. One might expect such a high concentration of phospholipid especially since the liver is known to be the key organ in fat metabolism (Peters and Van Slyke, 1946).

Another rather interesting point is the fact that milk contains a large amount of phospholipid in relation to cholesterol; this is indicated by the ratio phospholipid/cholesterol = 45. However, in relation to the total fatty acids, the amount of cholesterol in milk is relatively low, as is indicated by the ratio cholesterol/fatty acid $\times$ 100 = 0.3. The same ratio for buffalo blood has a value of about 12, which indicates there are appreciably greater amounts of cholesterol relative to fatty acid in blood than there are in milk.

Table 1 shows that there is an unusually high concentration of total fatty acids in the blood of the buffalo. There is, moreover, a rather large amount of cholesterol in the bison blood: 122 mg./100 ml. Since the bison is herbivorous, it might be anticipated that there would be a relatively small amount of blood cholesterol, such as one finds in the caribou. This is not so. It has been maintained by various workers that fat absorption is intimately related to the phospholipids contained in the wall of the alimentary canal (Bloor, 1943). In this connection it should be pointed out that the amount of phospholipid in the wall of the abomasum of the bison is unusually low, 0.87 per cent. Moreover, it is known that no absorption takes place in this part of the alimentary canal of ruminants (Dukes, 1947). It is suggested that the low concentration of phospholipid in the abomasum of the bison is in some way correlated with the fact that no absorption takes place through the walls of the alimentary canals in this area.

The various tissues from the bison can be arranged in different orders based on the values of the several lipid ratios. For example, if the bison tissues are arranged in order of descending values of the ratio, fatty acid/phospholipid, one finds that the abomasum wall is first, with the highest value for this ratio. In all probability, this results from the unusually low concentration of phospholipid in this area. On the low end of the scale is the liver, which has a very high concentration of phospholipids in relation to the total fatty acids. The other results are arranged in between.

If the tissues are arranged on the basis of descending order of values for the ratio, cholesterol/fatty acid, it is found that the spleen has first position and breast muscle the last. It is interesting to note that values for this ratio for heart muscle, neck muscle and breast muscle are practically identical. In view of the fact that the spleen is essentially involved in hematopoiesis, one might anticipate a large amount of cholesterol in relation to fatty acid.

Finally, if the tissues are arranged on the basis of decreasing values of phospholipid/cholesterol the liver is first in order and the spleen last. The other tissues fall in between these two. Here again is found evidence for the contention that the liver plays a central role in the turnover of fats. In relation to cholesterol, there is an extremely large amount of phospholipid in the liver. On the other hand, the spleen and the lungs are certainly not key organs in the metabolism of fats, and it is immediately apparent that the amount of phospholipids in relation to cholesterol in these latter tissues is small.

Further detailed discussions of the various lipid ratios and values for the bison are not warranted at this time. The primary purpose of this report was to publish information concerning the normal range of lipid values for different tissues in the mammal, *Bison bison*. These values have been estimated and are presented. Their chief worth lies in their use as possible base line values in any future experimental work on this species.

LITERATURE CITED

Bloor, W. R. 1943. Biochemistry of the fatty acids. Reinhold, New York. 387 p.

Dukes, H. H. 1947. The physiology of domestic animals. Comstock, Ithaca, New York. 817 p.

KELLOGG, C. E. 1939. Nutrition of fur animals *in* Yearbook of Agriculture, pp. 871-892. U. S. Government Printing Office, Washington, D. C.

PETERS, J. P. AND D. D. VAN SLYKE. 1946. Quantitative clinical chemistry. Interpretations. Vol. I. Williams and Wilkins, Baltimore. 1041 p.

PILGRIM, M. S. 1943. Alaska, its history, resources, geography, and government. Caxton Printers, Caldwell. 334 p.

WILBER, C. G. AND X. J. MUSACCHIA. 1950. A comparative study of lipids in arctic marine mammals. Jour. Mamm., 31: 162-167.

CHARLES G. WILBER AND THEODORE W. GORSKI, *Biological Laboratories, St. Louis University, St. Louis, Missouri.* (Present address: C. G. Wilber, *Chemical Corps Medical Laboratories, Army Chemical Center, Maryland.*) *Received May 10, 1954.*

[Supported by U. S. Air Force funds under provisions of Subcontract No. AF 33(038) 422-82049 E. O. No. 21-01-021]

TWO CALCULI FROM MULE DEER

The writers feel that description of two additional calculi from Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) may merit mention because of the paucity of records for deer calculi listed by Milton and Axelrod (Jour. Mamm., 32: 139–154, 1951) in their rather extensive review of calculi and other stones found in mammals.

One of these calculi was obtained by a hunter, Albert Erickson, of Price, Utah from a stomach of a doe which he killed November 21, 1953 in the Nash Draw area of eastern Utah. The hunter turned the "stomach stone" over to the senior author for identification. This calculus was egg-shaped in crossection both longitudinally and transversely. The three diameter measurements were 52, 45, and 30 millimeters. Externally the calculus is shiny and a yellowish brown color as is each of the several underlying layers. Chemically the layers consist of brushite ($CaHPO_4 \cdot 2H_2O$) which agrees with analyses of a calculus taken from a whitetail in Virginia and reported by Milton and Axelrod (*op. cit.*) and of another taken from a Wisconsin whitetail and reported by Burt (Jour. Mamm., 23: 335–336, 1942).

The second calculus was found on the ground by the junior author in the Duck Creek area of eastern Nevada in the spring of 1948. Although an old skeleton of a deer was a few feet distant the "stone" was not recognized at that time as a calculus nor of having been associated with the deer. It was not until a visual comparison was made with the Nash Draw calculus that this stone was identified. Separation of the calculus from the deer carcass probably resulted through the action of predators or scavengers. The original measurements of this stone could not be determined because a few of the outer layers had sloughed off due to shrinkage and weathering. The general shape, color, structure and chemical composition were identical to the first-described calculus. The nucleus of each calculus consisted of a chip of rock—what appeared to be limestone in the one from Nash Draw and quartzite in the one from Duck Creek.

The writers wish to acknowledge the assistance rendered by H. E. Petersen of the Chemical Laboratory of the U. S. Bureau of Mines, Salt Lake City, Utah in making the chemical analyses of the two calculi described in this paper. This note is a contribution from the Utah big game, livestock and range relationships study.—VERGIL DRANEY AND W. LESLIE ROBINETTE, *Utah State Fish and Game Department, Huntington, Utah and U. S. Fish and Wildlife Service, Salt Lake City, Utah.* *Received August 30, 1954.*

"PARROT MOUTH" IN ROCKY MOUNTAIN MULE DEER

The term "parrot mouth" or overshot jaw describes the condition in livestock where the upper jaw protrudes beyond the incisors of the mandible. The incisors register on or posteriorly to the dental pad rather than on the front angle as they normally do in ruminants. In a partial survey of the literature the writers have noted but a single mention of this anomaly in *Odocoileus* spp. Johnson (Jour. Mamm., 16: 69–70, 1935) reported a spike buck (*O. virginianus*) killed in the Adirondack area of New York State whose incisors met the upper jaws about one inch back of their normal point of contact.

TABLE 1.—*Mandibular measurements for parrot-mouthed and normal deer**

Class	Mandible (inches)	Diastema (inches)	Distance Maxillary Extends Beyond Mandible (inches)
Yearling doe			
parrot mouth	7.75	2.25	0.4
normal	8.14 ± 0.31 (7)	2.43 ± 0.09 (7)	
difference	0.39*	0.18**	
Two-year buck			
parrot mouth	8.25	2.19	0.6
normal	8.60 ± 0.17 (11)	2.63 ± 0.14 (11)	
difference	0.35**	0.44**	
Five-year male			
parrot mouth	8.62	2.50	0.65
normal	9.18 ± 0.10 (3)	2.88 ± 0.13 (15)	
difference	0.56**	0.38**	

* Measurements for normal deer listed with standard deviations and number of measurements (in parentheses). Differences between the parrot mouth and normal measurements significant at the 5% level are indicated by a single asterisk and at the 1% level by two asterisks. Mandibular lengths were from the angular process to the emergence point of the corner incisors. Diastema measurements were of the space between the cheek and incisor teeth.

The writers have noted eight mule deer (*O. hemionus hemionus*), four bucks and four does, in Utah with this affliction. The upper jaws in these animals protruded from about one-fourth to one inch beyond the lower jaw.

Muir, *et al.* (Canada Ag., Pub. 588, 7 p., 1937) states that "parrot mouth" is inherited as a simple recessive and both parents must carry the defect as a hidden trait. Four of the eight cases noted by the writers were deer taken by hunters from the Oak Creek area of central Utah. Two others were killed in the vicinity of Salt Lake City, another was killed near Manti, Utah, and the eighth died of malnutrition in Weber Canyon. The fact that four of the eight came from a restricted area lends credence to the hereditary nature of this defect.

Nordby (The National Woolgrower, 21, (2): 4, 1931) studying parrot mouth in domestic sheep raised the question of whether both jaws were affected or only one. Measurements of normal mandibles and three mandibles that we have saved from parrot-mouthed deer indicates that a shortened mandible is primarily responsible for the difference rather than an elongated maxillary (Table 1). Further observations of the jaws showed that much of the disparity in length of mandible is accountable to the diastema or that section between the cheek and incisor teeth. Whereas the diastema represents but about 31 per cent of the mandibular length in jaws from normal deer that we have measured, it accounted for 45, 73 and 58 per cent respectively of the disparity in the yearling doe, and in the 2-year and 5-year-old bucks. The upper and lower cheek teeth appear to mesh satisfactorily in the parrot-mouthed deer that we have examined, which also indicates that the diastema is largely accountable for the overshot condition.

We have no measure of the incidence of parrot mouth in Utah deer for no special effort has been made to look for the defect. Individuals having an overshot jaw, to the extent of a quarter of an inch or less, likely would be overlooked unless a specific search was being made. Pronounced cases of the anomaly are certainly not common in Utah—amounting probably to no more than a fraction of one per cent.

It was of interest to the writers that the general health and condition of the affected

deer did not seem noticeably different from normal animals in the same areas at the same season, which is contradictory to many observations of similar conditions in livestock.—W. Leslie Robinette and C. M. Aldous, *U. S. Fish and Wildlife Service, Salt Lake City, Utah. Received August 30, 1954.*

REVIEWS

Howes, Paul Griswold. The Giant Cactus Forest and Its World. Duell, Sloan and Pearce; New York—Little, Brown; Boston. xxx + 258 pp.; 52 plates, 1 color; 30 figs. 1954. Price, $7.50.

This is a charmingly written account of the biology of an unusual habitat. Mr. Howes is a keen observer and adds many bits of ecological information to the record in an interesting way. There are those who may take issue with some of the author's speculations concerning the meanings of what he saw in the daily life of the cactus forest, as when he says, "Again and again I have realized that rodents were never intended to be much of anything but food for other creatures." Nevertheless, these speculations are useful in stimulating the reader to think about the meanings of some of the observed facts.

There are many observations on mammals in this strange habitat, including ground squirrels, kangaroo rats, pocket mice, grasshopper mice, trade rats, rabbits, badgers and coyotes. Reptiles, amphibians, and birds are other vertebrates that play an important part in the life of the cactus world. Insects, other arthropods, and smaller animals are not neglected in their complex interrelations with the unusual plant life of the region.

The book is beautifully illustrated with over 150 photographs of the plant and animal life, although Plates 43 to 47 were omitted from the reviewer's copy. The plates are supplemented with many informative field sketches by the author. The wisdom of adding to the substantial cost of the book by including a color plate of the birds of the giant cactus forest may be questioned, although it completes the pictorial record in a splendid fashion.

As appendices the author adds some simple diagrams and charts of food interrelationships, data on climate, and a list of general references to desert life. All in all this interesting book is more than entertaining, it presents much new information.—W. Robert Eadie.

BRIEFLY NOTED

Allen, Shirley W. Conserving Natural Resources, Principles and Practice in a Democracy. McGraw-Hill, New York, ix + 347 p., 169 figs. 1955. Price, $5.50.

This is a general work on the college level that surveys current practice in the conservation of natural resources including those resources that are non-renewable. While resembling other currently available texts in its coverage, this book is unified by the philosophy of the single author. The text is copiously supplemented by well chosen photographs and figures. General bibliographies are presented for each chapter.

Black, John D. Biological Conservation with Particular Emphasis on Wildlife. Blakiston, New York, xiv + 328 p., 75 figs. 1954. Price, $5.00.

As the title indicates, this book on conservation is limited to renewable resources. It is divided into a number of sections. "Part 1. Basic Considerations" surveys the general problem and presents some basic ecology; "Part 2. The Environment" presents more ecology in relation to water and vegetation under chapter headings such as "Standing Water, Running Water, Grasslands and Wildlife", and "Forests". Parts 3, 4 and 5 make up the bulk of the book and are entitled respectively "Fish and Other Aquatic Animals," "Birds," and "Mammals." Under these headings are specific discussions of conservation problems and practices in relation to individual groups or species. A final chapter discusses the influence and responsibilities of Federal and State agencies in relation to conservation. Each chapter ends with a brief list of references, and there is a useful annotated bibliography in "Appendix

A". "Appendix B" is a guide to available, free, educational, conservation and wildlife films.

Woodbury, Angus M. PRINCIPLES OF GENERAL ECOLOGY. Blakiston, New York, viii + 503 p., 167 figs. 1954. Price, $6.00.

This is a textbook of general ecology aimed at upper level college students. The author has done a straightforward job of compressing the basic and general principles of ecology into a book suitable for a one semester course. The style of writing is uncomplicated and the text is easily understood by anyone who has had basic science courses. There is a minimum use of special terms. Complete citations for text references are listed in an appended bibliography, which supplies an introduction to the literature of ecology.

Stuart, Frank. A SEAL'S WORLD. McGraw-Hill, New York, 224+ p., illus. 1954. Price, $4.00.

This is a natural history adventure story of the life, wanderings, and adventures of a harp seal. Although it is a fictionalized account, a definite attempt is made to stay within the bounds of known factual material. In this way a great deal of information on the harp seal is presented while spinning a fascinating tale of ocean life.

Wiley, Farida A., editor. ERNEST THOMPSON SETON'S AMERICA. Devin-Adair Co., New York. xxiii + 413 pp., illus. 1954. Price, $5.00.

To those mammalogists and others whose early interest in natural history was aroused, enhanced and stimulated by the writings of Ernest Thompson Seton this book will bring pleasant memories. Consisting of a varied selection from Seton's published works, the book includes some of his biography, fictional animal stories, some mammal life histories, a discourse on tracking and trailing, art anatomy, zoo animals, accounts of some of the birds and mammals of Manitoba, and other excerpts.

Two included stories that are certain to strike chords in the memories of many are "Krag, The Kootenay Ram" and "Lobo, King of the Currumpaw."

Howells, William. BACK OF HISTORY. Doubleday and Company, Inc. Garden City, N. Y. 384 pp., illus. 1954. Price, $3.50.

This is the prehistoric story of mankind's development told in a simple and entertaining fashion by an anthropologist. By careful choice of facts and examples an unusually coherent picture is presented.

RECENT LITERATURE

(Conducted by David H. Johnson, Claude W. Hibbard, Charles P. Lyman, Richard H. Manville, and Henry W. Setzer)

[Reprints of this section may be purchased from the Corresponding Secretary]

AELLEN, V. Description d'un nouvel *Hipposideros* (Chiroptera) de la Côte d'Ivoire. Rev. Suisse Zool., vol. 61, no. 3, pp. 473–483. September, 1954. (New: *H. marisae*)

AKIYA, SHICHIRO, OTOMATSU HOSHINO, AND NOBUO MOTOHASI. Attempt to preserve freshness of whale meat with germicides. II. Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 1–10, illus. June, 1954.

ALLOUSE, BASHIR E. A bibliography on the vertebrate fauna of Iraq and neighbouring countries. I. Mammals. Publ. Iraq Nat. Hist. Mus., no. 4, pp. 1–31, 1954.

ANDERSON, SYDNEY. Subspeciation in the meadow mouse, Microtus montanus, in Wyoming and Colorado. Univ. Kansas Publ., Mus. Nat. Hist., vol. 7, no. 7, pp. 489–506. July 23, 1954. (New: *M. m. codiensis*, *M. m. zygomaticus*.)

ANDREW, WARREN. Age changes in the skin of Wistar Institute rats with particular reference to the epidermis. Amer. Jour. Anat., Philadelphia, vol. 89, no. 2, pp. 283–320, illus. September, 1951.

ANDREWARTHA, H. G., AND L. C. BIRCH. The distribution and abundance of animals. Univ. Chicago Press, 782 pp. 1954.

ANONYMOUS. Whales on show. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), Sandefjord, vol. 43, no. 8, pp. 457–459. August, 1954. (In Norwegian and English.)

BARNARD, K. H. A guide book to South African whales and dolphins. Guide South African Mus., no. 4, pp. 33. 1954.

BARNETT, LINCOLN. The world we live in: Part XI. The rain forest. Life, Chicago, vol. 37, no. 12, pp. 76–102, illus. September 20, 1954.

BARTHOLOMEW, GEORGE A., JR., AND JOSEPH B. BIRDSELL. Ecology and the protohominids. Amer. Anthropologist, vol. 55, no. 4, pp. 481–498. October, 1953.

BATEMAN, BOB. Observations on the natural history of the Leaf Bay-Fort Chimo region, Ungava, Quebec. Intermediate Naturalist, Toronto, no. 8, pp. 1–7, 1953.

BISCHOFF, ARTHUR I. Abnormal fetal development from a mule deer. California Fish & Game, vol. 40, no. 3, pp. 340–341. July, 1954.

BLAIR, W. FRANK. Mammals of the mesquite plains biotic district in Texas and Oklahoma, and speciation in the central grasslands. Texas Jour. Sci., vol. 6, no. 3, pp. 235–264. September, 1954.

BOBACK, A. Zur Frage des "Harnspritzens" beim Feldhasen, *Lepus europaeus* Pallas, 1778. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 78–79. April 1, 1954.

BOPP, PETER. Einige biologische Beobachtungen am Zweizehenfaultier, *Choloepus didactylus* (Linné, 1766). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, pp. 114–118, illus. July 1, 1954.

BOURLIÈRE, FRANÇOIS. Les adaptations à la vie aquatique chez les mammifères. La Nature, no. 3233, pp. 321–326. September, 1954.

BREATHNACH, A. S., AND F. GOLDBY. The amygdaloid nuclei, hippocampus and other parts of the rhinencephalon in the porpoise (Phocaena phocaena). Jour. Anat., London, vol. 88, pt. 3, pp. 267–291. July, 1954.

BROOKS, C. C., G. B. GARNER, M. E. MUHRER, AND W. H. PJANDER. Effect of some steroid compounds on ovine rumen function. Science, vol. 120, no. 3116, pp. 455–456. September 17, 1954.

BURT, WILLIAM HENRY. The subspecies category in mammals. Systematic Zoology, vol. 3, no. 3, pp. 99–104. September, 1954.

CABRERA, A. Los roedores argentinos de la familia "Caviidae". Publ. Escuela Vet., Facultad de Agron. y Vet. Univ. Buenos Aires, no. 6, pp. 93. June, 1954. (New: *Cavia aperea hypoleuca*, *Pediolagus salinocola cyniclus*.)

CAMERON, AUSTIN W. The mammals of southeastern Quebec. Provancher Soc. Nat. Hist. Canada, 1950–1951, pp. 20–86. 1953.

CARRARA, ITALO SANTIAGO. Lobos marinos, pingüinos y guaneras de las costas del litoral maritimo e islas adyacentes de la República Argentina. Ministerio de Educacion, Univ. Nac. de la Plata, pp. 191, illus. 1954. (Mimeographed)

CLARKE, ROBERT. Open boat whaling in the Azores. The history and present methods of a relic industry. Discovery Reports, Cambridge, vol. 26, p. 281–354, pls. 13–18. February, 1954.

CLARKE, ROBERT. A great haul of ambergris. Nature, London, vol. 174. no. 4421, pp. 155–156, illus. July 24, 1954. (Reprinted in Norsk Hvalfansgt-Tidende (Norwegian Whaling Gazette), vol. 43, no. 8, pp. 450–453; August, 1954).

CLARKE, ROBERT. Whales and seals as resources of the sea. Norsk Hvalfansgt-Tidende (Norwegian Whaling Gazette), Sandefjord, vol. 43, no. 9, pp. 489–510, illus. September, 1954. (In Norwegian and English.)

DALIMIER, PAUL. La morphologie de la chèvre sous l'influence de la domestication. Bull. Inst. Royal Sci. Nat. Belgique, Brussels, vol. 30, no. 13, pp. 1–12, illus. April, 1954.

DALQUEST, WALTER W., AND HENRY J. WERNER. The interscapular gland of a tropical fruit bat. Anat. Record, vol. 111, no. 3, pp. 345–353, illus. November, 1951.

DARLING, F. FRASER. Caribou, reindeer and moose in Alaska. Oryx, vol. 2, no. 5, pp. 280–285. August, 1954.

DASMANN, WILLIAM P., AND JAMES A. BLAISDELL. Deer and forage relationship on the Lassen-Washoe interstate winter deer range. California Fish & Game, vol. 40, no. 3, pp. 215–234. July, 1954.

DATHE, HEINRICH. Ringelrobbe, *Phoca hispida annellata* Nilsson, 1820, in der westlichen Ostsee. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, p. 33. January 1, 1954. (Supplementary note in vol. 2, no. 2, p. 81; April 1, 1954).

DATHE, HEINRICH. Eine Wildkatze, *Felis s. silvestris* Schreber, 1777, in Nordwestsachsen. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, p. 128. July 1, 1954.

DAVIES, D. V., AND W. C. OSMAN HILL. The abdominal portion of the alimentary system in *Hapalemur* and *Lepilemur*. Proc. Royal Soc. Edinburgh, vol. 65, pt. 2, pp. 182–203. July, 1954.

DAWBIN, W. H. Maori whaling. Norsk Havalfangst-Tidende (Norwegian Whaling Gazette), Sandefjord, vol. 43, no. 8, pp. 433–445, illus. August, 1954. (In Norwegian and English)

DEANE, H. W., AND C. P. LYMAN. Body temperature, thyroid and adrenal cortex of hamsters during cold exposure and hibernation, with comparisons to rats. Endocrinology, Springfield, Ill., vol. 55, no. 3, pp. 300–315. September, 1954.

DEINSE, A. B. VAN. The pelvic bones of Physeter macrocephalus L. Zool. Med. Rijksmus. Nat. Hist. Leiden, vol. 33, no. 4, pp. 25–32. June 9, 1954.

DIETERLEN, FRITZ. Über den Haarbau des Andenwolfes, *Dasycyon hagenbecki* (Krumbiegel, 1949). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, pp. 26–31, illus. January 1, 1954.

DORST, JEAN. Considérations sur le genre "Otomops" et description d'une espèce nouvelle de Madagascar (Chiroptères, Molossidés). Mem. Inst. Sci. Madagascar, ser. A, vol. 8, pp. 235–240, pl. 31. 1953. (New: *Otomops madagascariensis*)

EADIE W. ROBERT. Animal control in field, farm and forest. Macmillan Co., New York, pp. vii + 257. 1954.

EALES, N. B. The manus of the narwhal, *Monodon monoceros* L. Proc. Zool. Soc. London, vol. 124, pt. 2, pp. 201–211, illus. August 20, 1954.

EDWARDS, R. Y. Comparison of an aerial and ground census of moose. Jour. Wildlife Management, Ithaca, vol. 18, no. 3, pp. 403–404. July, 1954.

FINDLEY, JAMES S. Competition as a possible limiting factor in the distribution of *Microtus*. Ecology, Durham, vol. 35, no. 3, pp. 418–421, illus. July, 1954.

FOSTER, BRIS. Notes on a small collection of mammals from the Crow's Nest Pass region of Alberta. Intermediate Naturalist, Toronto, no. 8, pp. 20–22. 1953.

FREYE, HANS-ALBRECHT. Bermerkungen zum Genitalsystem des männlichen Bibers, *Castor fiber* L. Wissensch. Zeitsch. Martin-Luther-Universität Halle-Wittenberg, Jahrg. 2, Heft 11, pp. 911–915, illus. 1953?

FREYE, HANS-ALBRECHT. Beiträge zur funktionellen Anatomie des Biber-skelettes. Wissensch. Zeitsch. Martin-Luther-Universität Halle-Wittenberg, Jahrg. 3, Heft 5, pp. 1101–1135, illus. August 30, 1954.

FUJINO, KAZUO. On the serological constitution of the sperm and Baird beaked whales. (I) Blood groups of the sperm and Baird beaked whales. Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 105–120. June, 1954.

FUJINO, KAZUO. On the body proportions of the fin whales (*Balaenoptera physalus* (L)) caught in the northern Pacific Ocean (I). Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 121–163, illus. June, 1954.

GAFFREY, G. Zur Ernährungsweise des Wildkaninchens, *Oryctolagus cuniculus* (Linné, 1758). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, p. 80. April 1, 1954.

GAFFREY, G. Partieller Leukismus bei einer Brandmaus, Apodemus agrarius (Pallas, 1771). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, p. 81. April 1, 1954.

GANDAL, CHARLES P. Age determination in mammals. Trans. New York Acad. Sci., ser. 2, vol. 16, no. 6, pp. 312–314. April, 1954.

GEIS, AELRED D. Rabbit damage to oak reproduction at the Kellogg Bird Sanctuary. Jour. Wildlife Management, vol. 18, no. 3, pp. 423–424. July, 1954.

GERBER, R. Die Zweifarbige Fledermaus, *Vespertilio m. murinus* Linné, 1758, für Leipzig und Schandau nachgewiesen. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, p. 33. January 1, 1954.

GILBERT, PERRY W. The premandibular head cavities in the opossum Didelphis virginiana. Jour. Morphol., Philadelphia, vol. 95, no. 1, pp. 47–76. July, 1954.

GREEN, MORTON. A cynarctine from the Upper Oligocene of South Dakota. Trans. Kans. Acad. Sci., vol. 57, no. 2, pp. 218–220, illus. August 2, 1954. (New: *Ozetocyon*, *O. cuspidatus*.)

GUNTER, GORDON. Mammals of the Gulf of Mexico. Fishery Bull. U. S. Fish & Wildlife Service, vol. 55, no. 89, pp. 543–551. 1954. (Seal, manatee, cetaceans.)

HAGER, HERMANN. Die Cytoarchitektonik des Bulbus olfactorius des Igels, *Erinaceus e. europaeus* Linné, 1758. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, pp. 8–15, illus. January 1, 1954.

HAMILTON, J. E. Cetacea of the Falkland Islands. Comunic. Zool. Mus. Hist. Nat. Montevideo, vol. 4, no. 66, pp. 1–6. 1952.

HANSEN, RICHARD M. Molt patterns in ground squirrels. Proc. Utah Acad. Sci., Arts, & Letters, vol. 31, pp. 57–60. 1954.

HARDER, WILHELM. Einige Beobachtungen an gefangenen Waldmäusen, *Apodemus sylvaticus* (Linné, 1758). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 72–74. April 1, 1954.

HARRISON, R. S., AND A. R. HYETT. The development and growth of the placentomes in the fallow deer (*Dama dama* L.). Jour. Anat., London, vol. 88, pt. 3, pp. 338–355. July, 1954.

HART, JOHN D. The embattled beaver. Colorado Conservation, vol. 3, no. 4, pp. 6–10. July, 1954.

HEIM DE BALSAC, HENRI. Un genre inédit et inattendu de mammifère (Insectivore Tenrecidae) d'Afrique Occidentale. Comptes Rendus Acad. Sci., Paris, vol. 239, no. 1, pp. 102–104. July 5, 1954. (New: *Micropotamogale*, *M. lamottei*)

HEROLD, W. Boebachtungen über den Witterungseinfluss auf den Massenwechsel der Feldmaus. Zeitschr. Säugetierk., Berlin, vol. 19, nos. 1–2, pp. 86–107. July 30, 1954.

HIBBARD, CLAUDE W. Second contribution to the Rexroad fauna. Trans. Kans. Acad. Sci., vol. 57, no. 2, pp. 221–237, illus. August 2, 1954. (New: *Brachyopsigale*, *B. dubius*, *Prodipodomys rexroadensis*, *Peromyscus baumgartneri*.)

HOOIJER, D. A. Pleistocene vertebrates from Celebes. VIII. Dentition and skeleton of Cele-

bochoerus heekereni Hooijer. Zool. Verhandelingen, Rijksmus. Nat. Hist. Leiden, no. 24, pp. 46, pls. 6. June 25, 1954.

HOOPER, EMMET T. A synopsis of the cricetine rodent genus *Nelsonia*. Occas. Pap. Mus. Zool. Univ. Michigan, Ann Arbor, no. 558, pp. 12, September 17, 1954.

IMAIZUMI, YOSHINORI. Taxonomic studies on Japanese *Myotis* with descriptions of three new forms (Mammalia: Chiroptera). Bull. Nat. Sci. Mus. Tokyo, n.s., vol. 1, no. 1 (no. 34), pp. 40–58. March, 1954. (New: *M. mystacinus fujiensis, M. hosonoi, M. ozensis*).

ISSEL, W. Wiederfundzahlen beringter Fledermäuse. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, p. 127. July 1, 1954.

JANY, EBERHARD. Die Schwimmfähigkeit von Mäusen (Muridae). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 75–78, illus. April 1, 1954.

KALELA, OLAVI. Über den Revierbesitz bei Vögeln und Säugetieren als populationsökologischer Faktor. Ann. Zool., Soc. Zool. Bot. Fennicae "Vanamo", vol. 16, no. 2, pp. 48. 1954.

KENNERLY, THOMAS E., JR. Local differentiation in the pocket gopher (*Geomys personatus*) in southern Texas. Texas Jour. Sci., vol. 6, no. 3, pp. 297–329. September, 1954.

KEYS, CHARLES E. Phyletic relationships among some rodents with special consideration of *Sigmodon* based on embryolgical data. Trans. Kentucky Acad. Sci., vol. 15, nos. 1–2, pp. 1–11. July, 1954.

KILHAM, LAWRENCE, AND JAMES H. BELCHER. A device for safe handling of wild mammals in the laboratory. Jour. Wildlife Management, Ithaca, vol. 18, no. 3, p. 402, illus. July, 1954.

KOLB, ANTON. Biologische Beobachtungen an Fledermäusen. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, pp. 15–26, illus. January 1, 1954.

KROG, HILDUR, AND MILDRED MONSON. Notes on the metabolism of a mountain goat. Amer. Jour. Physiol., Washington, vol. 178, no. 3, pp. 515–516. September, 1954.

KÜHLHORN, FRIEDRICH. Säugetierkundliche Studien aus Süd-Mattogrosso. 2. Teil: Edentata, Rodentia. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 66–72, illus. April 1, 1954.

KÜHLHORN, FRIEDRICH. Gefügegesetzliche Untersuchungen an Neuweltaffen (*Cebus apella* L. und *Alouatta caraya* Humboldt). Zeitschr. Säugetierk., Berlin, vol. 20, no. 1, pp. 13–36. July 30, 1954.

KURTÉN, BJÖRN. On the variation and population dynamics of fossil and recent mammal populations. Acta Zool. Fennica, Soc. Fauna et Flora Fennica, no. 76, pp. 122. 1953.

KURTÉN, BJÖRN. The Chinese Hipparion fauna. Comment. Biol., Soc. Sci. Fennica, vol. 13, no. 4, pp. 82. 1954.

LA TOUR, G. DENNLER DE. The guanaco. Oryx, vol. 2, no. 5, pp. 273–279. August, 1954.

LAYNE, JAMES N., AND W. J. HAMILTON, JR. The young of the woodland jumping mouse, Napaeozapus insignis insignis (Miller). Amer. Midland Nat., vol. 52, no. 1, pp. 242–247. July, 1954.

LEEUWEN, L. VAN. On the characters of *Sorex exiguus* van den Brink as compared with those of *Sorex minutus* L. Proc. Kon. Ned. Akad. Weten., ser. C, vol. 57, no. 3, pp. 332–338. May–June, 1954.

LEYSON, BURR W., AND RUTH MANECKE. The zoo comes to you. Dutton, New York, 88 pp., illus. 1954.

LINDEMANN, WALDEMAR. Zur Rassenfrage und Fortpflanzungsbiologie des karpatischen Braunbären, *Ursus arctos arctos* Linné, 1758. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, pp. 1–8, January 1, 1954.

LINDNER, ERWIN. Zoo-Safari. Bericht der Deutschen Zoologischen Ostafrika-Expedition 1951–52. E. Schweizerbart, Stuttgart, pp. ix + 139, illus. 1954.

LONGHURST, WILLIAM M. The fecal pellet group deposition rate of domestic sheep. Jour. Wildlife Management, Ithaca, vol. 18, no. 3, pp. 418–419. July, 1954.

LUND, HJALMAR MUNTHE-KAAS. The Walrus (*Odobaenus rosmarus* (L.)) off the coast of Norway in the past and after the year 1900, together with some observations on its migrations and "cruising speed". Astarte, Zool. Dept. Tromsø Mus., no. 8, pp. 1–2, illus. July 25, 1954.

MAYER, WILLIAM V., AND EDWARD T. ROCHE. Developmental patterns in the Barrow ground squirrel, *Spermophilus undulatus barrowensis*. Growth, vol. 18, pp. 53–69, illus. 1954.

MCCARLEY, W. H. The ecological distribution of the *Peromyscus leucopus* species group in eastern Texas. Ecology, Durham, vol. 35, no. 3, pp. 375–379, illus. July, 1954.

MCCLUNG, ROBERT M. The unpredictable platypuses. Animal Kingdom, New York Zool. Soc., vol. 57, no. 4, pp. 110–111, illus. August, 1954. (Breeding behavior)

MCCLUNG, ROBERT M. Four babies from Alaska. Animal Kingdom, New York Zool. Soc., vol. 57, no. 4, pp. 120–124, illus. August, 1954. (Harbor seals and bald eagles)

MELTON, FRANK A. "Natural mounds" of northeastern Texas, southern Arkansas, and northern Louisiana. The Hopper, Oklahoma Geol. Survey, Norman, vol. 14, no. 7, pp. [87]–121 (mimeogr.), illus. (Opposes gopher origin)

MERTENS, R. Über asymmetrische Zeichnungen bei wildlebenden Säugern. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, pp. 32–33. January 1, 1954.

MILLER, RICHARD S. Food habits of the wood-mouse, *Apodemus sylvaticus* (Linné, 1758), and the bank vole, *Clethrionomys glareolus* (Schreber, 1780), in Wytham Woods, Berkshire. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, pp. 109–114. July 1, 1954.

MOORE, JOSEPH CURTIS. Fox squirrel receptionists. Everglades Nat. Hist., vol. 2, no. 3, pp. 153–160, illus. September, 1954.

MÜLLER, HEINRICH. Zur Fortpflanzungsbiologie des Hermelins (*Mustela erminea* L.) Rev. Suisse Zool., vol. 61, no. 3, pp. 451–453. September, 1954.

MÜLLER-USING, DETLEV. Simpsons Neuordnung der Mammalia in ihrer Bedeutung für die deutsche Säugetierkunde. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, pp. 102–109. July 1, 1954.

MYERS, K. Studies in the epidemiology of infectious myxomatosis of rabbits. II. Field experiments, August–November 1950, and the first epizootic of myxomatosis in the Riverine Plain of southeastern Australia. Jour. Hygiene, vol. 52, no. 1, pp. 47–59, illus. March, 1954.

NEUBAUR, F. Ziehende Fledermäuse. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, p. 31. January 1, 1954.

NISHIWAKI, MASAHARU, TAKASHI HIBIYA, AND SEIJI KIMURA. On the sexual maturity of the sei whale of the Bonin waters. Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 165–177, illus. June, 1954.

OGAWA, TEIZO. On the musculature of the sinus venosus and its continuation with the so-called conducting system of the whale's heart. Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 11–31, illus. June, 1954.

OGILVIE, STANLEY. Pronghorn profile. Colorado Conservation, vol. 3, no. 4, pp. 22–24, illus. July, 1954. (*Antilocapra*)

OLIN, GEORGE. Animals of the southwest deserts. Pop. Ser. Southwest Monuments Assoc., no. 8, pp. 112. 1954.

OMURA, HIDEO, AND KAZUO FUJINO. Sei whales in the adjacent water of Japan. II. Further studies on the external characters. Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 89–103, illus. June, 1954.

PALMER, RALPH S. The mammal guide: mammals of North America north of Mexico. Doubleday and Co., Garden City, New York, pp. 384, illus. August, 1954.

PEARSON, OLIVER P. Shrews. Scientific American, New York, vol. 191, no. 2, pp. 66–68, 70. August, 1954.

PETZSCH, H. Einige neue Beobachtungen an tauchenden Elba-Bibern, *Castor fiber albicus* Matschie, 1909, in Gefangenschaft. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 79–80. April 1, 1954.

PIRLOT, P. L. Pourcentages de jeunes et périodes de reproduction chez quelques rongeurs du Congo Belge. Ann. Mus. Royal Congo Belge, Tervuren, n.s., Sci. Zool., vol. 1 (Miscellanea Zoologica H. Schouteden), pp. 41–46. 1954.

PITMAN, CHARLES R. S. The influence of the Belgian Congo on the distribution of Uganda's primates, and some of their characteristics. Ann. Mus. Royal Congo Belge, Tervuren, n.s., Sci. Zool., vol. 1 (Miscellanea Zoologica H. Schouteden), pp. 47–55. 1954.

POHLE, HERMANN. Max Hilzheimer, 1877–1946. Zeitschr. Säugetierk., Berlin, vol. 19, nos. 1–2, pp. 66–82, pl. 5. July 30, 1954.

PRELL, HEINRICH. Gehörnte Esel, gehörnte Schweine und gehörnte Hyänen im klassischen Altertum. Zeitschr. Säugetierk., Berlin, vol. 19, nos. 1–2, pp. 108–116. July 30, 1954.

PRIGOGINE, A. Deux nouvelles races d'*Aethosciurus ruwenzori* Schwann du Congo belge. Ann. Mus. Royal Congo Belge Tervuren, n.s., Sci. Zool., vol. 1 (Miscellanea Zoologica H. Schouteden), pp. 69–73. 1954. (New: *A. r. schoutedeni*, *A. r. ituriensis*)

PRUITT, WILLIAM O., JR. Notes on the shorttail shrew (Blarina brevicauda kirtlandi) in northern lower Michigan. Amer. Midland Nat., Notre Dame, vol. 52, no. 1, pp. 236–241. July, 1954.

QUAY, W. B. The blood cells of Cetacea with particular reference to the beluga *Delphinapterus leucas* Pallas, 1776. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 49–54, illus. April 1, 1954.

RHODE, CECIL E. When giant bears go fishing. Nat. Geogr. Mag., Washington, vol. 106, no. 2, pp. 195–205, illus. August, 1954. (Alaskan brown bears)

RIECK, WALTER. Die Bestände des Muffelwildes, *Ovis musimon* Pallas, 1811, im Bundesgebiet. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 54–60, map. April 1, 1954.

ROBINSON, CYRIL S., AND FRED P. CRONEMILLER. Notes on the habitat of the desert bighorn in the San Gabriel Mountains of California. California Fish & Game, vol. 40, no. 3, pp. 267–271. July, 1954.

ROBINSON, KATHLEEN W. Heat tolerances of Australian monotremes and marsupials. Australian Jour. Biol. Sci., vol. 7, no. 3, pp. 348–360. August, 1954.

RODHAIN, J. Le *Thamnomys surdaster surdaster*, animal de laboratoire. Ann. Mus. Royal Congo Belge, Tervuren, n.s., Sci. Zool., vol. 1 (Miscellanea Zoologica H. Schouteden), pp. 74–76, illus. 1954.

ROKITANSKY, G. VON. Zweiter Fundnachweis von *Myotis bechsteini* (Leisler, 1818) für Österreich. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, p. 128. July 1, 1954.

SANBORN, COLIN CAMPBELL. Bats from Chimantá-Tepui, Venezuela, with remarks on *Choeroniscus*. Fieldiana, Zool., Chicago, vol. 34, no. 27, pp. 289–293. July 23, 1954.

SCHWANGART, F. Übersicht und Beschreibung der Hauskatzenrassen (Standards). Zeitschr. Säugetierk., Berlin, vol. 20, no. 1, pp. 1–12, pls. 1–3. July 30, 1954.

SIMPSON, GEORGE GAYLORD, AND H. TOBEIN. The rediscovery of Peale's mastodon. Proc. Amer. Philos. Soc., Philadelphia, vol. 98, no. 4, pp. 279–281. August 16, 1954.

SLIJPER, E. J. On the importance of measuring the thickness of the layer of blubber in whales. Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), Sandefjord, vol. 43, no. 9, pp. 510–516, illus. September, 1954. (In Norwegian and English.)

SMITH, DOUGLAS E., YEVETTE S. LEWIS, AND GEORGE SVIHLA. Blood clotting time and tissue mast cell number of the bat (*Myotis lucifugus*) in different physiological states. Proc. Soc. Exper. Biol. & Med., New York, vol. 86, no. 3, pp. 473–475. July, 1954.

SNYDER, DANA P. Skull variation in the meadow vole (*Microtus p. pennsylvanicus*) in Pennsylvania. Ann. Carnegie Mus., Pittsburgh, vol. 33, pp. 201–234. September 21, 1954.

STEGEMAN, LEROY C. The production of aspen and its utilization by beaver on the Hunt-

ington Forest. Jour. Wildlife Management, Ithaca, vol. 18, no. 3, pp. 348–358. July, 1954.

STEINBACHER, G. Zur Biologie des europäischen Wildschweins, *Sus scrofa* Linné, 1758. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, p. 126. July 1, 1954.

STEPHENS, MARIE. Otter research. Oryx, vol. 2, no. 5, pp. 320–324. August, 1954.

STRECKER, ROBERT L. Regulatory mechanisms in house-mouse populations: the effect of limited food supply on an unconfined population. Ecology, Durham, vol. 35, no. 2, pp. 249–253, illus. April, 1954.

STUART, FRANK. A seal's world. McGraw-Hill Book Co., New York, 224 pp., illus. May, 1954. (Harp seal.)

STUEWER, F. W. Ring-tailed rascal. Michigan Conservation, Lansing, vol. 23, no. 5, pp. 12–14. September, 1954. (Raccoon)

SULLIVAN, THELMA D., J. E. GRIMES, R. B. EADS, G. C. MENZIES, AND J. V. IRONS. Recovery of rabies virus from colonial bats in Texas. Public Health Repts., U. S. Public Health Service, Washington, vol. 69, no. 8, pp. 766–768. August, 1954.

SVIHLA, ARTHUR, AND HOWARD S. BOWMAN. Hibernation in the American black bear. Amer. Midland Nat., vol. 52, no. 1, pp. 248–252. July, 1954.

TABER, RICHARD D., AND RAYMOND F. DASMANN. A sex difference in mortality in young Columbian black-tailed deer. Jour. Wildlife Management, Ithaca, vol. 18, no. 3, pp. 309–315. July, 1954.

TAKASHIMA, H. Considerations on the change of animal life in Japan (II). Misc. Repts. Yamashina's Inst. Ornithol. & Zool., Tokyo, no. 4, pp. 146–155 (14–23). June, 1954. (Flying fox in Bonin Islands, mongoose in Ryukyu Islands; in Japanese with English summary.)

TALMAGE, ROY V., AND G. DALE BUCHANAN. The armadillo (*Dasypus novemcinctus*). A review of its natural history, ecology, anatomy and reproductive physiology. Rice Inst. Pamphlet, Monograph in Biology, Houston, vol. 41, no. 2, pp. viii + 135. July, 1954.

TALMAGE, R. V., G. D. BUCHANAN, F. W. KRAINTZ, E. A. LAZO-WASEM, AND M. X. ZARROW. The presence of a functional corpus luteum during delayed implantation in the armadillo. Jour. Endocrinol., London, vol. 11, no. 1, pp. 44–49. July, 1954.

THOMSON, A. P. D., AND S. ZUCKERMAN. The effect of pituitary-stalk section on light-induced oestrus in ferrets. Proc. Royal Soc., Cambridge, England, ser. B., vol. 142, no. 909, pp. 437–452. September, 1954.

THOMPSON, HARRY V., AND C. J. ARMOUR. Methods of marking wild rabbits. Jour. Wildlife Management, Ithaca, vol. 18, no. 3, pp. 411–414, illus. July, 1954.

TRATZ, EDUARD, AND HEINZ HECK. Der afrikanische Anthropoide "Bonobo", eine neue Menschenaffengattung. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, pp. 97–101, illus. July 1, 1954. (New: *Bonobo*, type *Pan satyrus paniscus* Schwarz)

UDA, MICHITAKA. Studies of the relation between the whaling grounds and the hydrographical conditions. (I). Sci. Repts. Whales Research Inst., Tokyo, no. 9, pp. 179–187. June, 1954.

UDAGAWA, T. The gem-faced civet occurring in the central part of Honshu. Misc. Repts. Yamashina's Inst. Ornithol. & Zool., Tokyo, no. 4, pp. 174–175 (42–43). June, 1954. (In Japanese, with English summary.)

ULLRICH, W. Das Verhalten des Schimpansen, *Pan tr. troglodytes* (Blumenbach, 1799), beim Sprung. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, pp. 124–126, illus. July 1, 1954.

URBAIN, ACH. Biologie de l'oryctérope. Ann. Mus. Royal Congo Belge, Tervuren, n.s., Sci. Zool., vol. 1 (Miscellanea Zoologica H. Schouteden), pp. 101–105, illus. 1954.

VAN HEERDT, P. F., AND J. W. SLUITER. The results of bat-banding in the Netherlands in 1952 and 1953. Natuur-hist. Maandblad, Utrecht, vol. 42, no. 11, pp. 101–104. November 30, 1953.

VAUGHAN, TERRY A. A new subspecies of bat (Myotis velifer) from southeastern California and Arizona. Univ. Kansas Publ., Mus. Nat. Hist., vol. 7, no. 8, pp. 507–512. July 23, 1954. (New: *M. v. brevis*)

VIDOVIC, V. L., AND V. POPOVIC. Studies on the adrenal and thyroid glands of the ground squirrel during hibernation. Jour. Endocrinol., London, vol. 11, no. 2, pp. 125–133. August, 1954.

WASSIF, KAMAL. The anterior process and the ossification of the malleus in mammals. Science, vol. 113, no. 2937, pp. 486–487. April 27, 1951.

WASSIF, KAMAL. On a collection of mammals from northern Sinai. Bull. Inst. Désert Egypte, vol. 3, no. 1, pp. 107–118, map. September, 1954.

WATSON, M. L., AND J. K. AVERY. The development of the hamster lower incisor as observed by electron microscopy. Amer. Jour. Anat., Philadelphia, vol. 95, no. 1, pp. 109–161. July, 1954.

WETTSTEIN, O. v. Über die Rötelmäuse Österreichs. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 3, pp. 118–124. July 1, 1954. (New: *Clethrionomys glareolus variscicus*)

WICHMANN, HEINRICH. Kleinsäuger als Feinde des Buchdruckers, *Ips typographus* (Linné, 1758) (Coleoptera). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 2, pp. 60–66. April 1, 1954.

WOLF, WILHELM. Spitzmäuse in Zwergmausnestern. Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, pp. 33–34. January 1, 1954.

WOOD, F. G., JR., AND JOSEPH CURTIS MOORE. The mystery whale of Vilano Beach. Everglades Nat. Hist., vol. 2, no. 3, pp. 136–142, illus. September, 1954. (*Ziphius*)

WOOD, MONTY. The mammals of the Mazinaw Lake area, Frontenac Co., Ont. Intermediate Naturalist, Toronto, no. 8, pp. 14–18. 1953.

WOOD, MONTY. A late breeding record for Blarina. Intermediate Naturalist, Toronto, no. 8, p. 29. 1953.

WOOLLAM, D. H. M., AND J. W. MILLEN. Perivascular spaces of the mammalian central nervous system. Biol. Rev., Cambridge, England, vol. 29, no. 3, pp. 251–283. August, 1954.

YEAGER, LEE E. Beaver mismanagement. Colorado Conservation, vol. 3, no. 4, pp. 11–15. July, 1954.

ZIMMERMANN, KL. Frass-Spuren von Gelbhalsmaus, *Apodemus flavicollis* (Melchior, 1834), und Waldmaus, *Apodemus sylvaticus* (Linné, 1758). Säugetierk. Mitteil., Stuttgart, vol. 2, no. 1, p. 34, illus. January 1, 1954.

COMMENTS AND NEWS

ANNUAL MEETING

The thirty-fifth annual meeting of the American Society of Mammalogists will be held at the University of Southern California at Los Angeles, June 12–16, 1955. The Directors will meet the evening of June 12 with registration the morning of June 13.

The Local Committee consists of William V. Mayer (Chairman), Robert M. Chew, Edward T. Roche, Kenneth Stager, George H. Pournelle and Henry Childs.

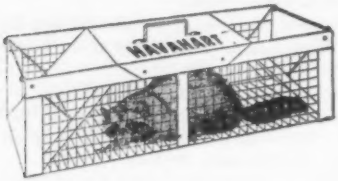
Rooms and meals will be available on the Campus.

Two dormitories will be allotted. One will be for males, the David X. Marks Hall, 3560 South Hoover Blvd. The second dormitory will be for women and family groups, the Town and Gown Hall, 666 West 36th Street. The cost will be $2.25 per person per night. Reservations should be made well in advance by writing to the Head Resident at the address given for each hall. No deposit will be required.

DATE OF ISSUE OF PREVIOUS NUMBER

Journal of Mammalogy, Vol. 36, No. 1 was mailed February 28, 1955.

HAVAHART HUMANE ANIMAL TRAPS



The *Allcock Manufacturing Company* has a large variety of humane animal traps. They have many sizes of live traps for those who are interested in catching the animals unharmed. The HAVAHART TRAPPING BOOKLET will be sent free of charge to anyone who requests it from the *Allcock Manufacturing Company, Ossining, New York.* HAVAHART traps have been used successfully by many who have been doing live-trapping experiments on small mammals. Write for the free booklet today.

Paleontology for the non-specialist

EVOLUTION of the VERTEBRATES

By EDWIN H. COLBERT, American Museum of Natural History and Columbia University. An authoritative general account of vertebrate evolution in terms that can be followed without previous training in anatomy or paleontology.

Avoiding advanced complexities or slanted, specialist approaches, the author outlines the broad features of evolution, dealing with both fossil and living forms. His readable account makes the book especially valuable for the non-specialist seeking a reference or survey of the rise of the vertebrates. *1955. 479 pages. 157 illus. $8.95. Also available in a textbook edition.*

Send now for an on-approval copy

JOHN WILEY & SONS, Inc. 440-4th Ave., New York 16, N.Y.

Contents—*Continued from cover 4*

General Notes—*Continued*

Late Fall Home Ranges of Three Golden Mice, *Peromyscus nuttalli* *Paul B. Dunaway* 297
The Rice Rat, *Oryzomys palustris texensis*, in Northwestern Arkansas *Wayne H. Davis and William Z. Lidicker, Jr.* 298
Extra Teeth in the Pygmy Mouse, *Baiomys musculus*....*Emmet T. Hooper* 298
Territoriality in Wild House Mice, *Mus musculus* L....*Peter Crowcroft* 299
Repeated Hibernation in a Captive Meadow Jumping Mouse *Gari C. Clough* 301
Notes on Chinchilla Liberations in California *John C. Voris, James D. Yoakum, and Charles F. Yocum* 302
Unusual Breeding of Cottontails in Pennsylvania.....*Glenn L. Bowers* 303
Coprophagy in the Swamp Rabbit.....*W. J. Hamilton, Jr.* 303
Evidence of Home Range of an Atlantic Bottlenose Dolphin *David K. Caldwell* 304
The Lipids in *Bison bison*..*Charles G. Wilber and Theodore W. Gorski* 305
Two Calculi from Mule Deer.....*Vergil Draney and W. Leslie Robinette* 308
"Parrot Mouth" in Rocky Mountain Mule Deer *W. Leslie Robinette and C. M. Aldous* 308

Reviews..... 310
Recent Literature..... 312
Comments and News..... 319

SUGGESTIONS TO AUTHORS

The *Journal of Mammalogy* publishes original papers with significant new content on any phase of the science of mammalogy. While authors need not necessarily be members of the society, it is suggested that individuals publishing serious papers in this field should consider carefully the desirability of associating themselves with the American Society of Mammalogists.

Papers are generally published in order of receipt with some exceptions at the discretion of the editor. Papers over twenty printed pages in length are rarely published because of costs and limitations of space. When partly subsidized, such papers may occasionally be published at the discretion of the editorial committee.

Photographic illustrations (half-tones) and tabular matter are strictly limited because of high costs of printing. Half-tones for decorative purposes, or interest only, will not be published; they should illustrate some point or fact, best shown in this way, and essential to the exposition of the paper. Tabular matter should contain data not repeated in text.

1. All manuscripts should be typewritten on white bond paper (8½″ x 11″ or 8″ x 10½″) with *all material, including titles, quotations, and literature cited, double spaced*. All margins should be at least one and one-half inches wide and pages should be numbered at the upper right corner. Carbon copies will not be accepted, nor will originals on onion-skin paper.

2. Titles are best if short as an aid to bibliography. Ten words should ordinarily be a maximum and less will usually serve.

3. Acknowledgments are included in the text; footnotes are avoided. Note the position for authors' names at the beginning and authors' addresses at the end of the article.

4. The bibliographic style used in recent Journal issues should be noted carefully and followed in "Literature Cited." In general, the bibliographic style will follow the suggestions made in the report of the A. I. B. S. Publications Committee, the A. I. B. S. Bul., 2(2): 21-23. Fewer than six references should be inserted in parentheses in the text, giving author, publication, volume, paging, and year, but not title unless a book. See recent issues for style.

5. Tabular matter should be arranged as simply as possible to fit Journal page size. Note style and place for title of table in recent issues. It is not always necessary to present all data gathered. The author should exercise some judgment as to what data are essential or of general interest. Tables should be typed on separate sheets at the end of the paper and *should not be placed in the running text.*

6. Line drawings or graphs should not be made on excessively large sheets. While some reduction is desirable, an original drawing or graph twice the size of the intended cut is ample. Photographic copies of drawings or graphs may not reproduce as well as the original. The original is preferred by the editor. Large sheets are cumbersome to handle and ship, and increase postage costs. Labels must be planned to be easily legible when reduced. Lines must be solid black, not gray, to reproduce well. Graphs on cross section paper should be made on paper with pale blue lines.

7. Photographs for reproduction should be sharp, with high contrast, and printed on glossy paper. A size of 4″ x 5″ is ordinarily most easy to arrange. The editor prefers them unmounted. Each should be identified by a notation on the back, lightly in pencil. Legends should be typed as paragraphs, in sequence, on a separate sheet at the end of the article. It is often possible to crop photographs extensively to remove non-essential areas such as sky, foreground, background, etc.

8. A brief, concise, and informative summary is advisable at the end of the paper.

9. Proof should be read very carefully immediately upon receipt and returned promptly, with manuscript, to the editor. While errors should be corrected, the galley proof is not the place for editorial changes by the author. Necessary changes are best at the end of a paragraph, or as a new paragraph.

10. Arrangements for reprints are *made by the author with the publisher* at time of receipt of proof. A form is supplied for ordering personal or institutional supplies of reprints. Fifty reprints, without covers, are supplied, free to the author of a major article. These may be obtained only if the author orders enough to bring the total number of reprints to 100.

SALE

Back Numbers of JOURNAL OF MAMMALOGY

Vol. 1, no. 5, each	$2.50	Vol. 20, no. 3, each	$2.00
Vol. 3, no. 1, Lithoprinted	2.00	Vols. 22–26, each	5.00
Vol. 4	6.00	Vol. 27, nos. 2, 3, 4, each	1.25
Vol. 6	6.00	Vol. 28	5.00
Vols. 7–19, each	5.00	Vol. 29, nos. 3, 4, each	1.25

Vols. 30–33 ..... $5.00 each

A discount of *20 per cent* is allowed members in good standing.

Prices are subject to change without notice; orders will be filled only as copies are available.

INDEX TO JOURNAL OF MAMMALOGY

The index to the first 20 volumes, 1919–1939 inclusive, of this Journal is still available. Paper cover, $2.50; cloth, $3.50.

The ten-year index, 1940–1949, is now available. Paper cover, $3.25; cloth, $3.75.

RECENT LITERATURE AND MEMBERSHIP LIST, REPRINTS FOR SALE

Reprints of the section on *Recent Literature* are for sale at 18¢ per number or 70¢ per volume. Supply available beginning with Volume 11 (1930)

Send orders for any of above to GEORGE C. RINKER, Corresponding Secretary, DEPARTMENT OF ANATOMY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN, *but made payable to the American Society of Mammalogists.*

CONTENTS

A Revised Classification of the Rodents ..... *Albert E. Wood* 165
Histology and Cytochemistry of Skin Gland Areas in the Caribou, *Rangifer* ..... *W. B. Quay* 187
Antlerless Mule Deer Bucks ..... *W. Leslie Robinette and Jay S. Gashwiler* 202
Some Factors Affecting Fluctuations of *Microtus* and *Peromyscus* ..... *E. W. Jameson, Jr.* 208
Observations on the Nature of the Decline in Numbers of Two *Microtus* Populations ..... *Gillian K. Godfrey* 209
Contribution to the Life History of *Sorex vagrans* in Montana ..... *Ronald R. Clothier* 219
Distribution of Mice and Shrews in a Colorado Montane Forest ..... *Olwen Williams* 221
Observations on the Life Histories of Panama Bats ..... *Prentice Bloedel* 239
Observations on the Mexican Free-tailed Bat, *Tadarida mexicana* ..... *Philip H. Krutzsch* 238
Survival and Movements of Banded Big Brown Bats ..... *James R. Beer* 242
Distribution and Status of the Wolverine in Montana ..... *Fletcher E. Newby and Philip L. Wright* 249
Mammal Observations at Lower Back River, Northwest Territories, Canada ..... *H. L. Gunderson, W. J. Breckenridge and J. A. Jarosz* 254
Rats of Arno Atoll, Marshall Islands ..... *Joe T. Marshall, Jr.* 259
Records of *Kogia breviceps* from Texas, with Remarks on Movements and Distribution ..... *Gordon Gunter, Carl L. Hubbs, and M. Allan Beal* 263
New Sagebrush Vole, Genus *Lagurus*, from Utah ..... *Lyle C. Dearden and M. Raymond Lee* 270
Two New Subspecies of Antelope Ground Squirrels from Utah ..... *Richard M. Hansen* 273
Skull of Fossil Camelid from American Falls Lake Bed Area of Idaho ..... *Marie L. Hopkins* 278
General Notes 283
Electrocardiogram of the Raccoon ..... *Charles G. Wilber* 283
Electrocardiographic Studies on the Opossum ..... *Charles G. Wilber* 284
A Simple Permanent Livetrap Plot for Shrews ..... *C. H. Buckner* 286
A Record of the Smoky Shrew, *Sorex f. fumeus* Miller, in South Carolina ..... *Albert Schwartz* 286
Condylura cristata from the Coastal Plain of South Carolina ..... *William C. Grimm* 288
Myotis austroriparius in Arkansas ..... *Wayne H. Davis, William Z. Lidicker, Jr., and John A. Scalander, Jr.* 288
Myotis subulatus leibii in Missouri ..... *Wayne H. Davis and William Z. Lidicker, Jr.* 288
Status of *Myotis grisescens* in Florida ..... *Dale W. Rice* 289
The Leafchin Bat in Arizona ..... *Lee D. Beatty* 290
Butterflies and a Kitten ..... *G. C. Tener* 290
Remarkable Age Attained by a Bobcat ..... *F. Donald Carter* 290
Food Habits of the Newfoundland Red Fox ..... *Donald G. Dodds* 291
Records of the New Mexican Bridled Weasel in Kansas ..... *Marvin D. Schwilling* 292
Observations on the Ring-tailed Cat ..... *Robert L. Edwards* 292
Dichromatism in Michigan Rodents ..... *Richard H. Manville* 293
Weights of Adult Gray Squirrels ..... *Hans G. Uhlig* 294
Gray Squirrels Feeding on Samaras of Elm ..... *W. W. Judd* 296
Notes on the Thirteen-lined Ground Squirrel in Utah ..... *Merlin L. Killpack* 296

Continued on page 331